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Boletines y Trabajos de la Sociedad de Cirugía de Córdoba (Argentina), I, No. 7, 1940.

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The University of Chicago. The Medical Schools. Announcements for the Fiftieth Anniversary Sessions of 1940–1941 (Vol. XL, No. 15). Chicago, 1940.

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bone graft is brief, to the point, and clearly advances the author's views. The remaining portion of the book is devoted chiefly to the various uses of the bone graft in rather rare cases, such as the insertion of grafts to take the place of bone tumors that have been removed for malignancy, and loss of bone from other causes. Ingenious methods are advocated for the use of the bone graft to replace bone in congenital absences of bone. The use of the bone graft in plastic operations of the face is also discussed. For the correction of leg inequality, the author cautions that leg-lengthening is at best a hazardous procedure. He describes the operative arrest of growth of the epiphysis by using a bone graft across the line to close the epiphysis. The author's arthrodesing bone-grafting operation for the knee is, in reality, merely an erasion buttressed by two bone grafts. After the knee is prepared, another incision is made over the crest of the tibia to receive the bone grafts. Evidently, Dr. Albee has no fear of contamination of this wound from the one in the knee. To most surgeons, this would seem a definite danger. The author believes that future arthroplasties may be attempted even after arthrodesis for tuberculosis and, therefore, plans his arthrodesing operation accordingly. Arthrodesing bone-grafting operations for the small bones of the foot, ankle, and shoulder are well presented.

This book is filled with interesting material and, backed up as it is by the long experience of a skillful, resourceful, and seasoned orthopaedic surgeon, is particularly valuable. The frequent claims regarding priority, and the use of the personal pronoun are at times a bit irritating, but the fact that this field of surgery has been steadily advancing and has gone far beyond the early dreams of the workers in that field, as mentioned by Dr. H. Winnett Orr in a foreword, is due more to the industry and devotion to its cause of Dr. Albee than to anyone else, and the reviewer would be the last to withhold from him even the least of credit. His work has been an inspiration to all surgeons working in this field and the book places them even further in debt to Dr. Albee.

THE 1940 YEAR BOOK OF INDUSTRIAL AND ORTHOPEDIC SURGERY. Edited by Charles F. Painter, M.D. Chicago, The Year Book Publishers, 1940. $3.00.

The establishment of The Year Book of Industrial and Orthopedic Surgery is evidence of the recognition of the development of this specialty in recent years. Probably no branch of surgery has developed to a greater extent in scope, progress, and the recognition of its importance than traumatic surgery. This development, together with the growth of orthopaedic surgery, has added a large number to those who occupy themselves with these two closely allied subjects. The recent advances in this field have also stimulated interest among a large group of general surgeons, who will welcome the information in the form presented in this volume. With this new addition to their series of Year Books, the publishers have recognized the expansion in these branches of surgery and also the common interest of the orthopaedic and traumatic surgeons. It was a fortunate idea to unite these two divisions of surgery in this presentation, for they form a definite group.

The publishers have been fortunate in obtaining Dr. Painter as editor of this volume. His endorsement and judgment ensure its scientific and practical character.

The status of traumatic and orthopaedic surgery, represented by the present accepted methods of treatment of the more important bone and joint affections, many of which demand major operative procedures, are given in sufficient detail to demonstrate the advances which have been made in recent years. The smaller and less difficult, although perhaps no less important subjects, are presented with the same character and thoroughness, and with sufficient direction for diagnosis and treatment to be helpful to the general surgeon and practitioner.

Orthopaedic surgeons who have kept in touch with the literature will find much of benefit in these reviews which are thorough and clearly expressed, and those who have not been able to follow the recent literature will find the needed information on these special subjects in a form of which they can make practical use. Two hundred and seventy-nine papers have been selected and these are supplemented by 299 illustrations. Opera-

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FIG. 3

Photomicrograph (× 12) of tissue obtained on the second postoperative day from a rat of Group A (normal except for the fracture), shows sealing of the medullae of both fragments by a cordon of fibrin continuing in the periosteum across both ends of the fractured bone.

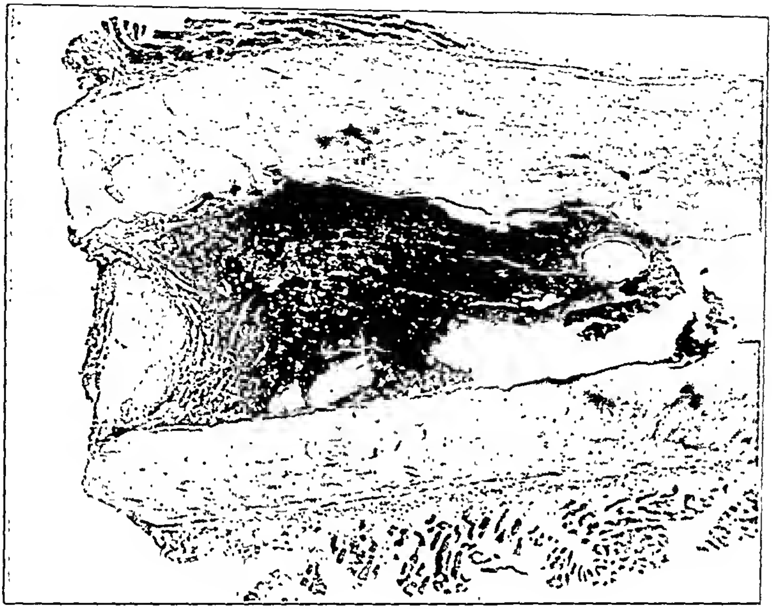

FIG. 4

Photomicrograph (× 25) of tissue obtained on the second postoperative day from a spayed rat, shows a plug of cortical bone in the medullary cavity. Could this be a potential cause of non-union? The periosteum is thickened.

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The Journal of Bone and Joint Surgery

CALCIFICATION AND OSSIFICATION

I. Calcification in the Callus in Healing Fractures in Normal Rats *

BY MARSHALL R. URIST, M.S.†, BALTIMORE, MARYLAND, AND FRANKLIN C. McLEAN, M.D., CHICAGO, ILLINOIS

From the Johns Hopkins Medical School, Baltimore, Maryland, and the Department of Physiology, University of Chicago, Chicago, Illinois

This and the following paper [27] present the results of histological observation of the progress of calcification in the healing of experimental fractures in rats. The observations have been made upon fractures in normal rats on adequate diets, and in rachitic rats subjected to various experimental procedures for the purpose of controlling calcification, and the correlation of this process in the fracture callus with the same process in other parts of the bone.

There is an extensive literature upon the microscopic anatomy of healing of both accidental and experimental fractures. Wieder [30] Bast, Sullivan and Geist [1], Blaisdell and Cowan [3], and Downs and McKeown [11] have described the healing process in animals maintained on adequate diets. In the past, studies of calcification have depended, as a rule, upon the staining reactions of decalcified tissues, or upon a combination of these and roentgenological techniques. Examples of the latter are Ham, Tisdall and Drake [19], Goisman and Compere [18], and Compere, Hamilton, and Dewar[8]. These methods, while adequate for study of the advanced stages of calcification, have not been reliable for observation of the details and time relationships of the earliest stages.

A new approach to the study of calcification in the callus, and more particularly of those phases of the phenomenon which have not been accessible by previous methods, has been made possible by the routine described by McLean and Bloom [24] for the sectioning and staining of undecalcified sections of bone. Since previous knowledge has been deficient

* This work was aided by a grant from the Josiah Macy, Jr., Foundation.
† Henry Strong Denison Scholar for 1940–1941.

concerning the earlier stages of calcification, and since the methods here employed are peculiarly adapted to their study, the chief emphasis in these papers is upon a detailed consideration of these earlier stages.

The authors have found that the relationship of calcification to the development of osseous tissue is the same in the callus of healing fractures as in other examples of osteogenesis. This idea is not new, but has resulted in the past in carrying over to consideration of the callus errors of observation and interpretation made originally upon growing bone. In textbooks of pathology [21] and in studies of bone repair [3, 12, 30] it is stated that the formation of calcified bone in the callus is preceded by the growth of osteoid. This study will show that the new osseous tissue is calcifiable when it is laid down, and that under optimum conditions a preliminary stage of uncalcified osteoid is not typical of bone formation in the callus.

METHODS

The observations in this and the following paper [27] are based upon microscopic studies of tissues prepared by five different routines. Routines 1 and 2 were used for all experiments; 3, 4, and 5 were employed in particular experiments which required special methods.

1. Tissues fixed in Zenker-formol were embedded in nitro-cellulose, decalcified, and cut serially at ten micra, stained in hematoxylin-eosin-azure II, or hematoxylin and eosin, and by the Mallory-azan method.

2. Tissues fixed in neutral formalin were embedded in nitro-cellulose, sectioned serially, and stained with silver nitrate, hematoxylin, and eosin, according to the routine described by McLean and Bloom [24].

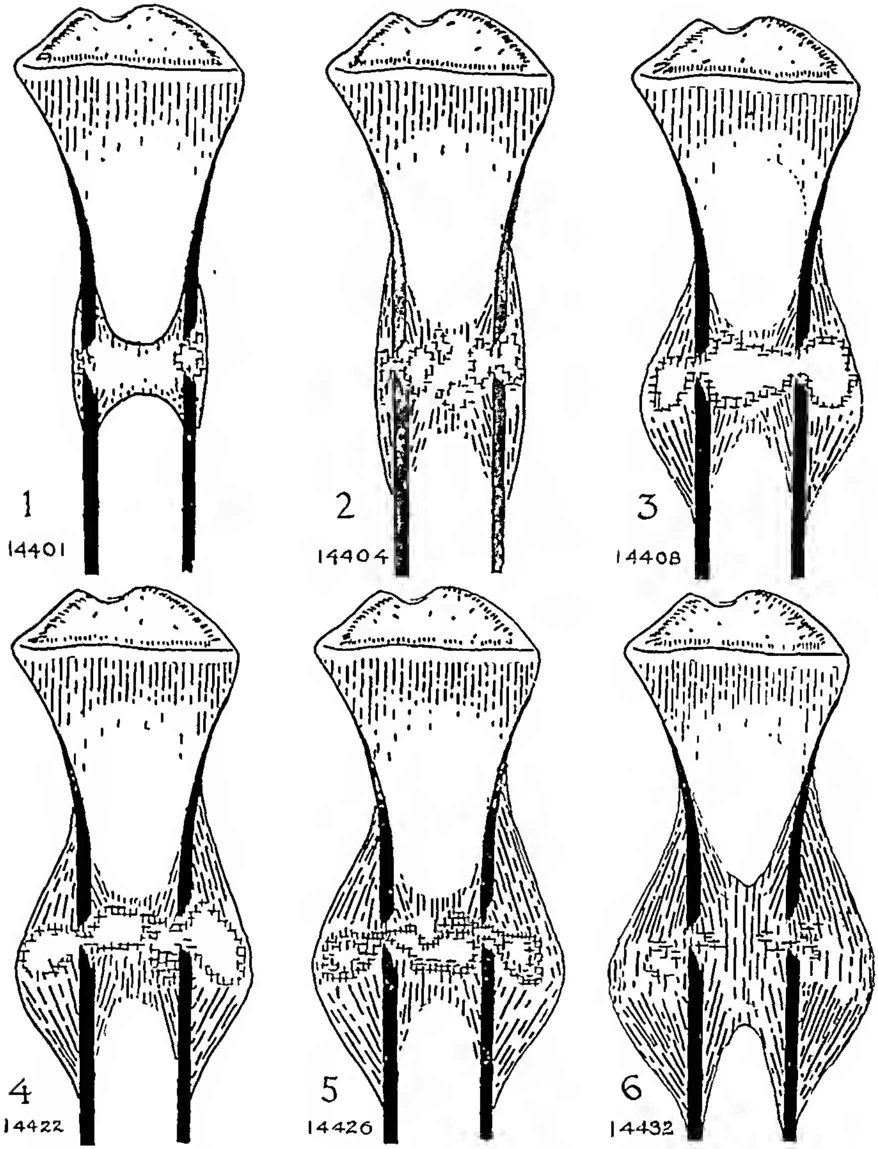
3. Frozen-dried tissue [14] (frozen in liquid air and dried in a vacuum at 30 degrees centigrade) infiltrated with 60-degree paraffin, were cut undecalcified at 15 to 20 micra, and impregnated (a) with 2-per-cent. silver nitrate followed by thorough washing and counterstaining in hematoxylin and eosin, or (b) with 40-per-cent. silver nitrate, and studied immediately after washing in water.

4. Unfixed, hand-cut sections were impregnated with 5-per-cent. silver nitrate, dehydrated in alcohol, and cleared in xylene.

5. Tissues stained supravitally with 2-per-cent. sodium alizarin sulphonate were fixed in neutral formalin, sectioned manually in 50-per-cent. alcohol, and cleared in isosafrol.

Fractures of the right tibia were prepared by destroying the continuity of the shaft about one centimeter under the secondary spongiosa. The technique consisted of grasping the right tibia between the tips of the index fingers and the thumbs and bending across the lateral diameter until the cortex snapped as would a glass tube. The cortex ends were replaced in a position as normal as possible. In most cases there was no laceration of the periosteum.

No attempt was made to immobilize the site of the injury or the animal.



Diagrammatic representation of deposits of bone salt in tibiae of growing rats, fractured at the age of forty-nine days. The rats had been fed on Bills' diet. Vertical hatching represents calcification of spongy bone, and cross hatching, calcified cartilage matrix. The light broken lines represent the usual limits of the epiphyseal cartilage, spongiosa, and fracture callus, respectively.

Fig. 1: two days after injury; Fig. 2: four days; Fig. 3: eight days; Fig. 4: twelve days; Fig. 5: eighteen days; and Fig. 6: union at twenty-four days.

EXPERIMENTAL

Fifteen litters of normal rats in addition to numerous individual normal rats given fractures as controls in other experiments, were used in these experiments. All were weaned at the age of twenty-one days to Bills' [2] stock diet. At seven weeks the right tibiae were fractured and allowed to heal for varying periods of time. Included within the series were healing fractures fixed at four-hour intervals during the first day, at

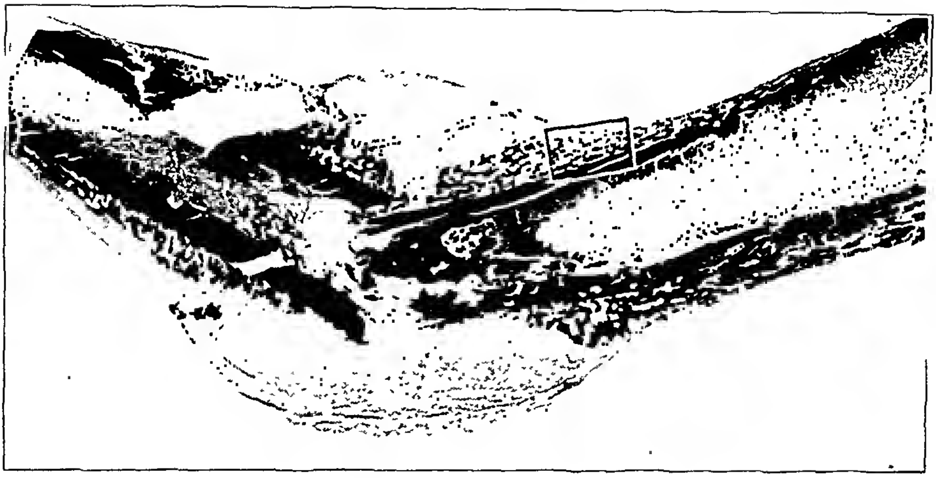


Fig. 7

Photomicrograph (× 8) of longitudinal section through fracture of undecalcified tibia of rat after six days of healing. Subperiosteal and subendosteal new bone are in contact with fibrocartilaginous callus, which is everywhere uncalcified except at points of contact with new bone. Rectangle indicates area of *Fig. 8.* (Silver nitrate hematoxylin eosin was the stain used for all sections illustrated.)

twelve-hour intervals during the second day, and at daily intervals thereafter until the twenty-eighth day.

The typical course of the healing of such fractures, considerably oversimplified, is illustrated diagrammatically in Figures 1 to 6, and may be briefly summarized here. The first reaction to the injury is essentially a sterile inflammation, which is the consequence of trauma and hemorrhage.

Fig. 8

Photomicrograph (× 94) of section through new bone originating from periosteum, from area indicated by rectangle in Fig. 7. *Po* indicates periosteum, and *Sh*, shaft. Early, granular calcification in the process of the formation of bone in contact with the periosteum is seen. The remainder of the bone, including the shaft, is fully calcified, without osteoid borders.

At four to eight hours after the bone is broken the defect is filled and surrounded by extravasated blood, hemorrhagic débris, and inflammatory exudate, including leukocytes. At twenty-four hours there is reparative new formation of connective tissue, which is at first ordinary granulation tissue, in the sense of Marchand [23], but which continues to proliferate, and to form dense fibrous connective tissue. A part of this differentiates further to form hyaline cartilage and fibrocartilage, and a part remains undifferentiated. The new tissue as a whole is here called the fibrocartilaginous callus.

At the same time that these changes are taking place in and near the defect in the bone, formation of new bone begins under the periosteum and endosteum, at some distance from the fracture line. This new bone invades and replaces the fibrocartilaginous callus, and leads to bony union at about the twenty-fourth day. Whether or not cells arising from the ordinary connective tissue of the callus have osteogenic potencies, cells arising from the deep or cambium layer of the periosteum, and from the endosteum, play the greater part in the production of new bone. Repair of fractures depends upon a variety of cells and of reparative processes, with, as will be seen, considerable variation in detail in the manner in which calcified bone is produced. The process as a whole is an excellent example of *organization* of diverse means to a common end,—in this case the healing of the fracture by bony union.

The Procallus

The procallus of an injured bone, as described by many writers [3] is now recognized by most investigators as identical with the inflammatory and early growth reactions to injury elsewhere in the body [26]. There have, however, been suggestions [20] that a "local calcium excess" in the early callus stimulates osteogenesis, which implies that deposition of the bone salt precedes rather than follows formation of bone.

Undecalcified sections of twenty-four-hour to forty-eight-hour fractures in normal young animals, stained with silver nitrate, fail to disclose deposition of bone salt in the inflammatory tissue. The initial blood clot is replaced by granulation tissue by the third day after the injury, and without hyalinization or calcification of any of the fibrin or hemorrhagic débris. The procallus thus becomes the fibrous callus.

Ossification

Once the initial inflammatory reaction to the injury is completed, resulting in the formation of a fibrocartilaginous mass in and around the defect in the bone, the essential process is the invasion of this mass from without by osteogenic tissue, and its replacement by bone. The picture is complicated by changes which occur within the callus prior to its invasion by bone, and by numerous variations in the detail of the invasion process.

Ossification begins at some distance from the fracture line, where there is a relatively slight primary reaction to the injury. Here the pic-

ture of the first step leading to bridging the fracture defect with new bone is that of uncomplicated intramembranous bone formation, originating from the deep layers of the periosteum and endosteum, and forming a collar of new bone around and within the shaft (Fig. 7). This new bone elevates the periosteum and endosteum, and forms a new growth which is wedge-shaped in longitudinal section, with the thin edge of the wedge farthest removed from the line of fracture. The new growth of bone reaches the callus, which by this time has undergone internal changes, invades it, and eventually replaces it with spongy bone.

So far this is a conventional description of the healing of a fracture. At this point, however, it must be emphasized that the intramembranous bone just described *is calcified as it is laid down*, and that under optimum conditions for the repair of bone is not seen as uncalcified osteoid (Figs. 8, 9, 10, and 11). There is first formed a fibrillar interstitial substance between the cytoplasmic processes of osteoblasts proliferating from the deep layers of the periosteum and endosteum. When first seen these fibers are rather loosely arranged in bundles, and may be slightly basophile. They are quickly transformed into a dense acidophile and homogeneous-appearing substance, in the meshes of which the cells with their communicating processes remain. At this stage the cells are bone cells, or osteocytes, and the interstitial substance is bone matrix. Calcification begins while the collagenous fibers are still loosely arranged, and before they have assumed the homogeneous appearance characteristic of bone matrix. The bone salt is usually seen first as isolated granules, the trabeculae later becoming uniformly calcified (Fig. 9).

A delay in calcification may occur. In addition to the many instances in which we have demonstrated calcification beginning simultaneously with the deposition of bone matrix, we have seen a number of animals in which in some areas of the callus there was a stage of uncalcified osteoid tissue, which later became calcified. On the basis of the histological findings, this was almost to be classified as a minimal form of rickets. These findings could not be correlated with the diet, as littermates receiving the same diet did not display osteoid, and none of the animals showed other signs of rickets. As will appear later in this paper, we attribute this sporadically occurring lag in calcification to an insufficient local supply of bone minerals, rather than to lack of calcifiability in the matrix.

The size and structure of the callus which has replaced the procallus at and near the site of injury and the amount of cartilage included within the callus depend, to a large degree, upon the extent of the initial injury, and upon the amount of trauma to which the site of the fracture is subsequently exposed [28, 30]. Glücksmann [17] has shown *in vitro* that pressure and tension stresses contribute to chondrogenesis. Young animals develop more abundant cartilage than older animals [6]. Rats develop more cartilage in the callus than do guinea pigs with identical injuries. We found cartilage in the callus in each of more than 400 rats with fractures of the tibia, and in several litters of rats with fractured ribs. In our experiments the fragments of the tibia were not immobilized, and no at-

tempt was made to control the activity of the animals; consequently callus formation, including formation of cartilage, may be assumed to have been at a maximum.

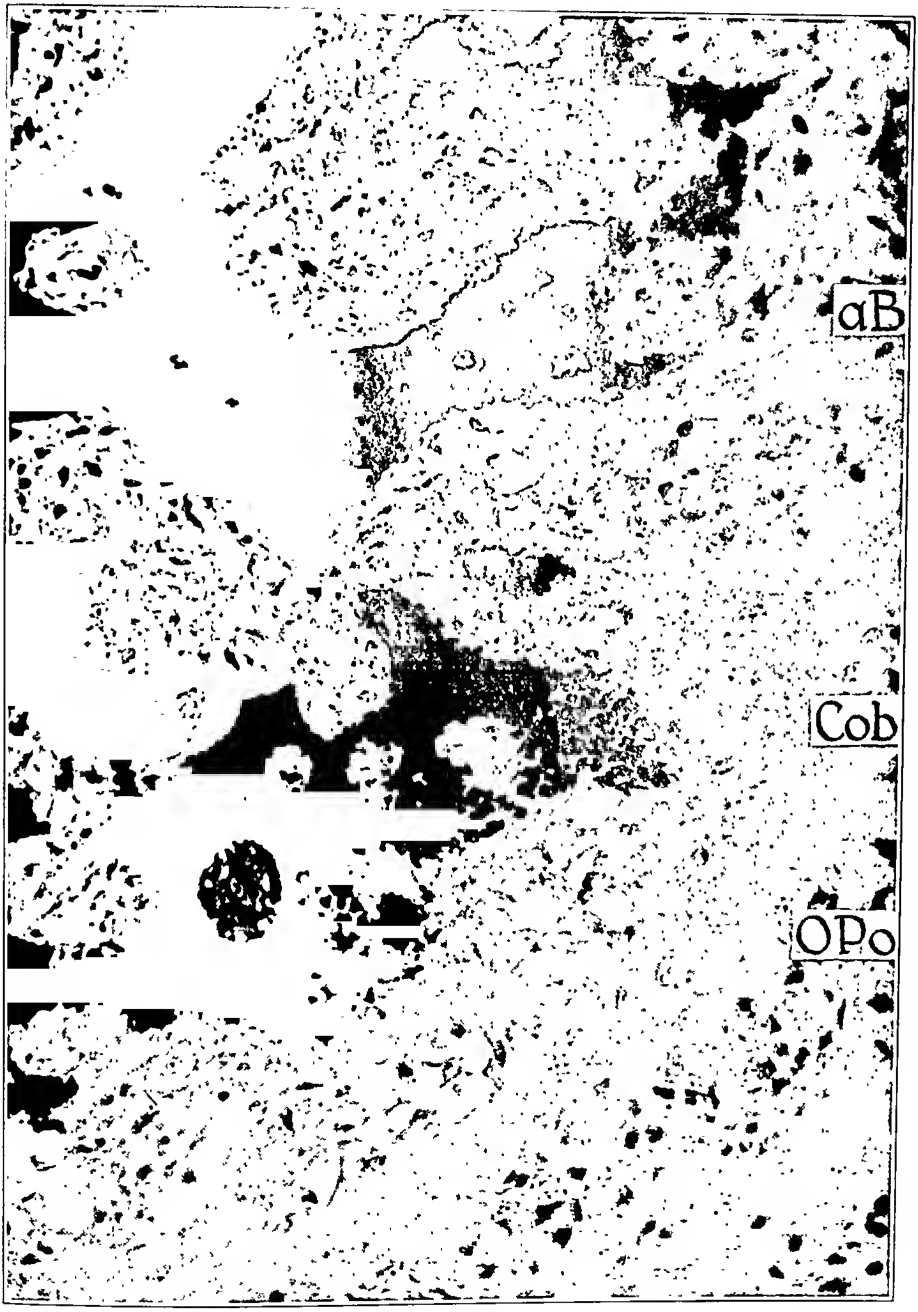


Fig. 9

Photomicrograph (× 390) of tangential section through the junction of the periosteum with bone, in an area similar to that shown in Fig. 8, after eight days of healing of a fracture of the tibia in a rat. *OPo* indicates the osteogenic layer of the periosteum; *Cob*, the zone in which new bone matrix, (*aB*) is being formed; *aB*, radiating bundles of collagenous fibers in process of formation and of calcification of subperiosteal bone. There has probably been a small amount of leaching of bone salt from lightly calcified matrix in zone *Cob*.

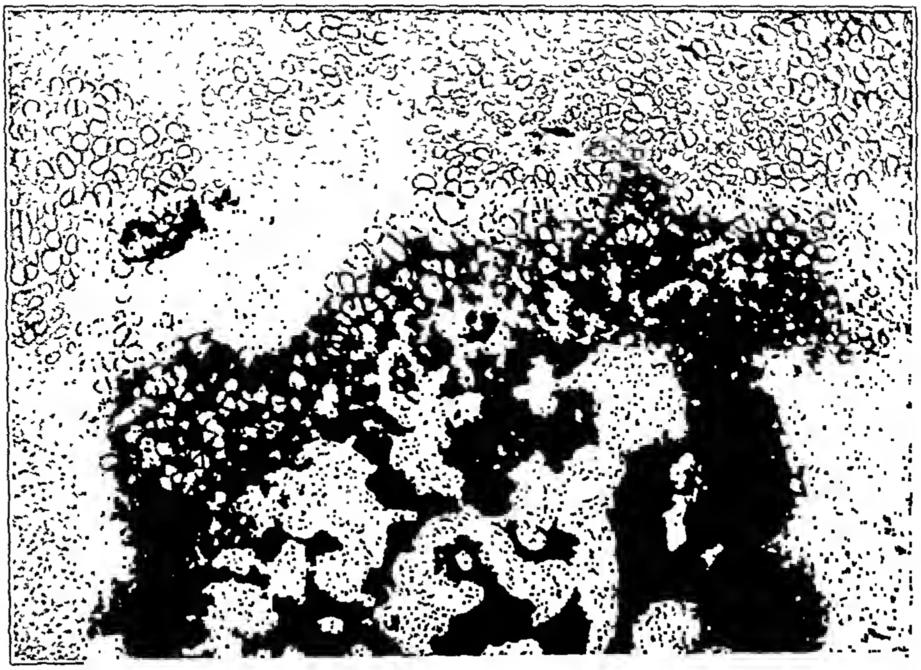


Fig. 10

Photomicrograph (× 80) of section through fibrocartilaginous callus in tibia of rat, after ten days of healing, shows invasion of hypertrophic cartilage by new subperiosteal bone. In this instance, which is exceptional, the process closely resembles that of intracartilaginous ossification in the embryo and in the growth of long bones. Cartilage is calcified in advance of invading bone, and there are suggestions of a primary spongiosa. There are no osteoid borders on the bone.

Cartilage appears in the callus from the second to the fourth day following the injury, by which time subperiosteal and subendosteal bone formation have begun, but may be at some distance from the fibrous mass. Small cartilage cells, comparable to the row-mother cells [9] of the epiphyseal cartilage appear within the mass of fibrous tissue. They arise in the fibrous connective tissue of the callus, undergo frequent mitosis, and produce cells which form nodular masses of hyaline cartilage. The nodules increase in size, and in part coalesce. Each nodule contains cells in various stages of development, with the more fully grown cartilage cells arranged generally toward the periphery of the nodules. Owing to the fusion of individual nodules, sections through the mass as a whole include cells in all stages of development, with the arrangement of the cells within the nodules obscured. In the final stages of development the cells increase in size, the cytoplasm becomes vesicular, and the nuclear chromatin is reduced in amount. In this stage they resemble the cells of the calcifying embryonic cartilage, and the cells of the zone of provisional calcification of the epiphyseal cartilage (Fig. 10). They are referred to as fully grown [10], hypertrophic [13], or vesicular [29].

When the new bone advancing from the periosteum and endosteum reaches and surrounds the fibrocartilaginous callus, the latter consists of a mass of dense tissue, composed in part of undifferentiated connective tissue, in part of fibrocartilage, and in part of the hyaline cartilage just described. Invasion of all these tissues occurs simultaneously, and ad-

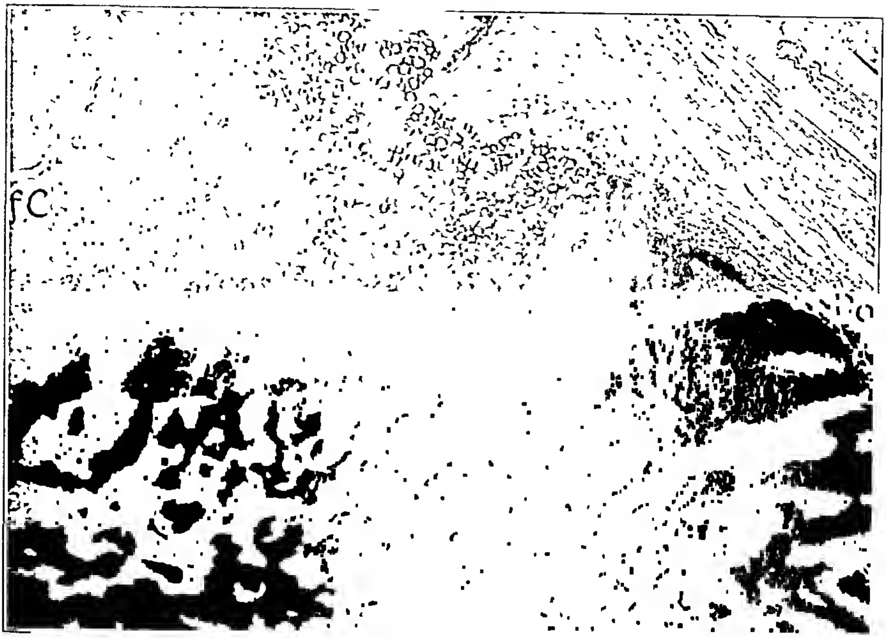


Fig. 11
Photomicrograph (× 44) of section through periosteum and fibrocartilaginous callus in the tibia of a rat, after ten days of healing of fracture, shows invasion of hyaline cartilage and of fibrocartilage by new subperiosteal bone. *Po*, indicates periosteum; *fC*, fibrocartilage. Immature hyaline cartilage is being removed and replaced by bone, by the same process as that in removal of fibrocartilage. In some areas calcification of cartilage matrix precedes replacement by bone, but along a wide front immature hyaline cartilage in the process of removal is calcified only very superficially. No osteoid borders on bone are seen.

vances centripetally from the periphery of the callus. The general character of the process of invasion is essentially the same for the different types of tissues to be replaced by bone, though there is considerable variation in detail (Figs. 10 and 11).

In general the character of the invasion is that of intramembranous bone formation, but differs from the uncomplicated process just described by the fact that here a considerable amount of tissue has to be resorbed. The bone matrix formed by the invading osteogenic cells frequently incorporates cells of the fibrous tissue or of the fibrocartilage, and utilizes them as a framework for the formation of trabeculae of spongy bone. The intervening tissue is resorbed and replaced by blood vessels and the primitive marrow associated with osteogenesis. The newly formed bone matrix is calcifiable as soon as it is formed, and begins to calcify at once. There is, however, no random calcification of fibrous tissue, or of fibrocartilage as such. The great mass of the tissue remains at first uncalcified, and is involved in the calcification process only as bone advances into it.

Where hyaline cartilage is encountered by the invading tissue, the general process of invasion is the same as that just described,—that is, there is new formaton of spongy bone upon a framework of persisting cartilage, with removal of the intervening tissue. To a variable extent this process resembles that of the intracartilaginous ossification seen in the

first days following the injury, become surrounded by macrophages and foreign-body giant cells containing phagocytosed particles of bone or of bone salt (Fig. 12). A few of these may be found as early as the third or fourth day in the granulation tissue enveloping the ends of the cortex. They become numerous between the fifth and the tenth days, and usually decrease in number thereafter. The most marked degree of phagocytic activity, with respect to particles of bone, is observed in fractures complicated by excessive fragmentation of the shaft. In a number of specimens we have seen particles of decalcified necrotic cortical bone (Fig. 13) and also partially decalcified dead cortical matrix containing crystalline aggregates of bone salt. Usually the bone fragments continue to break down into smaller and smaller particles and the bone salts and the dead bone matrix appear to dissolve at the same or nearly the same time.

Resorption and reconstruction of the section of the shaft enclosed in callus begins with the first formation of the subperiosteal intramembranous bone, and continues throughout the growth and regression of the callus. As a result of these processes the shaft, initially composed of compact bone, becomes at fifteen to twenty-five days of healing almost as porous as spongy bone. The vascular canals of Havers and Volkmann appear enlarged and filled with osteoclasts and osteogenic tissue. In roentgenograms the striking difference between the density of the outer shaft and the callus-enclosed shaft creates the impression of the well-known "atrophy of the cortical ends" of healing fractures. The formation of osteoclasts is almost exclusively limited to the activity of living bone tissues. Such osteoclasts as are found in the vicinity of the necrotic ends of the cortex are formed in enlarged vascular canals, and in crypts, which, prior to the injury, may have been occupied by osteogenic cells. Osteoclasts have not been observed to contain bone salt.

DISCUSSION

The chief contributions of this paper are with reference to the time relationships of calcification in the processes leading to the healing of fractures, and to the nature of tissues in which calcification occurs. Contrary to the usual view it has been shown that the formation of osteoid, or uncalcified osseous tissue, is not a necessary step in the formation of the bony callus. The new bone matrix is calcifiable when it is formed, and under optimum conditions calcification begins as the matrix is deposited. In this respect the process is identical with that in the normal embryogenesis or histogenesis of bone.

The healing of a fracture imposes an added burden upon the calcifying mechanism. Except under optimum conditions, general and local, the added burden may exceed the capacity of this mechanism, a condition which is manifested by the appearance of osteoid because of a lag in calcification. The significance of this finding has been discussed in a previous paper [24] with reference to the normal growth of bone, and need not be considered further here.

No special effort has been made, in this paper, to add to current knowledge concerning the histogenesis of the new bone which leads to union of a fractured bone. However, our preparations demonstrate invasion of the fibrocartilaginous callus by new bone, which calcifies as it advances into the callus mass, and afford striking evidence that the bone originates outside of this mass. The process is analogous to the intracartilaginous growth of bone, in that remnants of the invaded tissue are made use of and converted into bone matrix by the invading osteogenic cells. It is also similar to the intracartilaginous growth of bone in that the process is essentially one of removal and replacement of the fibrocartilaginous callus, rather than of its transformation into bone originating from the connective-tissue cells of the callus itself. According to our observations, new intramembranous bone is formed chiefly from the deep or cambium layer of the periosteum and from the endosteum, including the osteogenic cells within the haversian canals. If the fracture is in or near the spongy bone new bone arises from this source as well, and the bony callus is frequently continuous with the spongiosa. We have made no effort to prove or disprove the origin of bone from the osteocytes of the compact bone, but have not seen evidence that this was possible under the conditions of our experiments.

During the healing of a fracture a number of tissues, all of mesenchymal origin, arise in the callus. Calcification does not occur in a random fashion in these tissues, but is confined to tissues recognizable as bone matrix and as the matrix of hyaline cartilage. As stated above, the bone matrix is calcifiable when formed, and calcification begins in it while it is being laid down. In the case of cartilage matrix, the factors leading to calcification are somewhat more complex. Calcifiability is conferred upon the matrix of hyaline cartilage when the adjacent cartilage cells reach a stage recognizable as fully grown or hypertrophic. In this respect the hyaline cartilage of the callus resembles that in the epiphyseal cartilage plate [24] and in the embryonic cartilage models of bones [4], but calcification occurs in this matrix only when contact between the cartilage and the invading bone is established. Owing to the irregular distribution of the hypertrophic cartilage cells, resulting from the formation of nodular masses of cartilage, calcifiable cartilage matrix may be formed within the cartilage mass at some distance from the invading bone, while part of the cartilage matrix in contact with the invading bone is not calcifiable. Under these conditions some of the calcifiable matrix will not calcify, while the unprepared matrix, being invaded by bone, will calcify only when converted into bone matrix. In this respect it behaves in the same way as does fibrous tissue or fibrocartilage.

The extent to which the orderly sequence of events in the healing of a fracture depends upon calcification does not immediately become apparent from a study of fractures in normal animals. The interdependence of calcification and of the formation of normal osseous tissue is considered in detail in the paper which follows [27].

In addition to formation of new bone, the healing of a fracture involves resorption and reorganization of pre-existing cortical bone and of bone tissues formed provisionally in the callus. In these respects also there is a resemblance to the normal formation and growth of bone. In the case of the fracture, however, there is the additional necessity of the removal of necrotic bone. According to our observations, the latter process occurs by a process of liquefaction of both the organic and inorganic elements of bone, in which the inorganic substance may be removed in advance of the organic matrix, but in which osteoclasts play no part.

Macklin [22] and Chiariello [7], using trypan blue, and Micotti [25], administering lithium-carmine, studied the activity of macrophages in the callus at various stages of healing of fractures. Macklin interpreted his observations as indicating that the phagocytes ingest some, at least, of the products resulting from liquefaction of the callus, but states "that the liquefied bone salts are phagocytosed by macrophages seems entirely doubtful".

We have demonstrated the engulfment of particles of bone, including their bone salt, within macrophages and foreign-body giant cells, and have found that the most marked degree of activity is observed in fractures complicated by excessive fragmentation of the shaft. Gersh [15, 16] has shown that colloidal calcium phosphate may be removed from the blood stream by the macrophages of the liver and spleen, and Bloom and McLean [5] have demonstrated bone salt in the macrophages of the bone marrow under various conditions of rapid resorption of bone. A similar phenomenon occurs also during the liquefaction of necrotic fractured bone. Large fragments of dead bone excite a foreign-body reaction in the surrounding tissues, while smaller particles of dead bone or bone salt free from matrix may be phagocytosed by macrophages. These phenomena will be discussed further in a later paper, reporting our investigations upon the fate of dead bone implanted within the callus.

In contrast to the resorption of necrotic bone in the absence of osteoclasts, but in the presence of foreign-body giant cells, the resorption of living bone, where reorganization is to take place, is accompanied by the presence of large numbers of osteoclasts. Bone salt has not been seen to be phagocytosed by these cells. This finding is in agreement with those in other conditions associated with the rapid resorption of bone [5].

SUMMARY AND CONCLUSIONS

1. The healing process in the fractures observed is essentially one of formation of a fibrocartilaginous callus in and around the defect in the shaft, and the subsequent invasion, removal, and replacement of the fibrocartilaginous mass by new bone arising from the cambium layer of the periosteum and from the endosteum.

2. The progress of calcification in this process has been observed by impregnation of undecalcified sections with silver nitrate. By this method, which is extremely sensitive for bone salt, no deposition of salt is observed in the procallus, or prior to the formation of osseous tissue.

3. Bone matrix is formed subperiosteally and subendosteally, first at some distance from the fracture line, at about the second or third day following a fracture. It is calcified as it is laid down under optimum conditions with no appreciable interval between its formation and the deposition of bone salt within it. As the new bone invades the fibro-cartilaginous callus, it removes the fibrous tissue, fibrocartilage, and hyaline cartilage, replacing them by bone matrix. In this process remnants of the invaded tissue may be utilized and converted into bone matrix by the invading osteogenic cells. In all instances the new matrix is calcifiable as soon as it is recognizable as osseous tissue.

4. A lag in calcification of newly formed osseous tissue may occur. This is attributed to failure in the supply or transport of bone minerals, rather than to lack of calcifiability in the bone matrix.

5. The matrix of hyaline cartilage becomes calcifiable when the adjacent cartilage cells become vesicular or hypertrophic. The calcification of cartilage matrix is further conditioned by its relationship to the bone tissue invading the fibrocartilaginous callus. Only matrix in contact with the invading bone calcifies, and, if the matrix has not been made calcifiable by hypertrophy of the adjacent cells, it calcifies only when converted into bone matrix by the advancing osteogenic process.

6. Only tissues recognizable as bone matrix or cartilage matrix calcify in the callus. There is no random calcification in the fibro-cartilaginous callus, the great mass of which remains completely free from bone salt except where it is invaded and converted into bone from its periphery.

7. Particles of bone, including their bone salt, have been demonstrated in foreign-body giant cells and in macrophages during the resorption of necrotic bone. Fragments of dead cortical bone have been observed to undergo decalcification in advance of the disintegration of the bone matrix. This differs from the process of resorption of living bone, in which the bone mineral and organic matrix are removed simultaneously. No phagocytic activity of osteoclasts, either for particles of bone or for bone salt, has been demonstrated.

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MICROSCOPIC CHANGES AFTER INTERNAL FIXATION OF TRANSCERVICAL FRACTURE OF THE FEMUR

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Pathological changes and resistance to former methods of treatment, peculiar to intracapsular fracture of the hip, account for the widespread acceptance of the principles of internal fixation now in vogue. Despite the interest evinced in these injuries there are, in the literature, very few complete pathological studies of the fracture site so treated. It is our purpose to describe the microscopic findings in such a postmortem specimen. It was obtained from an elderly woman fifty-two days after injury, and forty-three days after transfixation by a Smith-Petersen nail. Death was probably due to a cardiovascular complication.

Palmer, in 1934, reported the result of a histological examination of the hip region from a woman, aged seventy, who had died of some disease unrelated to the injury, barely three months after fixation by a Smith-Petersen nail. In spite of the marked, and still active, absorption of the neck, and almost complete necrosis of the head, healing was progressing satisfactorily. Bony union had commenced in the distal fragment through metaplastic bone formation in tissue intimately bound up with its periosteal-synovial coverings. The regenerative processes of the spongiosa of the necrotic head were taking place through the marrow of the head, which had become revascularized by vessels from capsule periosteum, and not through callus growing in from the distal end of the fracture. The rustless steel nail, though partially extruded (12 millimeters) due to the absorptive processes in the neck, did not have any untoward effect upon the spongiosa or the reparative processes.

Another specimen, studied by Jones and Lieberman in 1938, was obtained from a female, aged fifty-two, eight days after fracture and only seven hours after fixation with a Jones screw. Death was due to probable multiple pulmonary emboli. The fracture involved the base of the neck and the lesser trochanter. The gross specimen revealed, besides the linear defect due to the insertion of the screw, a large triangular defect in the neck which was filled with brownish granular detritus, and marked by a complete absence of endosteum. Histologically there was almost complete necrosis of the neck along with focal areas of necrosis in the head. They felt that the widespread necrosis, which was observed in their case, may be present in varying degrees in all cases. It is this factor which probably puts this lesion in a class by itself, since the screw was certainly not responsible for these changes. They concluded "that sometimes this condition is a pathological fracture, and that the same fault which causes the fracture is the one responsible for delayed healing or even complete non-union."

FIG. 1

Photograph of postmortem specimen taken November 23, 1938.

CASE REPORT

Mrs. Lula R. (E1944) a white female, whose stated age was sixty-five years, was admitted to the St. Joseph Hospital on October 2, 1938, several hours after her injury. According to her medical attendant, Dr. H. W. Carle, she had suffered for years from an extensive vascular disease with concomitant hypertension. She was poorly nourished and appeared to be about seventy-five years of age. The general examination revealed a cataract of the left eye, edentulous jaws, funnel breast, scattered pulmonary râles, a systolic apical bruit with regular rhythm, and a blood pressure of 222/122. The left lower extremity presented the usual picture of a typical varus subcapital fracture. The temperature was 100 degrees, the pulse ninety-six and respiration twenty-two. Laboratory investigations revealed nothing relevant. Except for a tendency toward development of a sacral decubitus, she responded favorably to preliminary Russell traction. Her temperature, pulse, and respiration became normal one week after admission.

On October 11, 1938, under spinal anaesthesia, and roentgenographic control a three and one-half inch White rustless-steel Smith-Petersen nail was inserted following Leadbetter's method of manipulation and reduction. A postoperative roentgenogram showed excellent reduction (valgus), impaction of the fragments, and optimum low position of the nail. Postoperatively she ran an irregular low-grade fever which gradually returned to normal in a week. The traction and dermal sutures were then removed. On the following day she was permitted to sit up over the edge of the bed. She was discharged on November 4, 1938. The patient continued to make good progress at home. She was permitted to sit up in a chair daily, to stand with aid several times a day, and was encouraged to exercise the limbs in bed. On November 22, 1938, she suddenly complained of severe abdominal discomfort, headache, and vomiting. Coma and death occurred on the following day. The hip specimen was obtained at the mortuary several hours later.

HISTOLOGICAL STUDY *

Gross Pathology

The subcapital fracture of the femoral neck was firmly transfixed by a metal pin (Figs. 2-A and 2-B), the head of which protruded from the lateral femoral cortex just below the vastus lateralis ridge. The fracture fragments were well apposed. There was an apparent one-eighth inch distal displacement of the distal fragment due to valgus and impaction of the femoral head. Inferior to the fracture site a thin layer of fibrous tissue continuous with the periosteum bridged across the fragments. There was no evidence of periosteal callus. About one square centimeter of cortical plate was missing from the superior aspect of the femoral neck. This appeared to have been lost during the recovery of the specimen. The specimen was mounted in plaster-of-Paris, the pin was extracted, and then frontal sections were cut with a band saw (Fig. 3).

On frontal section it was evident that an early stage of bony union had been attained. Fibrous marrow and a multitude of minute trabeculae characterized the fracture area. Except for some small scattered areas and a narrow subchondral zone, the marrow of the

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capital epiphysis was fatty; all other marrow in the specimen appeared to be grossly hematogenous. Only a slight degree of osteoporosis was present. The articular cartilage was nowhere denuded or fibrillated, but was somewhat dull and in most areas opaque. The articular cortex was grossly intact. Surfaces of the bone, adjacent to flanges of the Smith-Petersen nail, were smooth and presented no porosis or sclerosis detectable by gross examination.

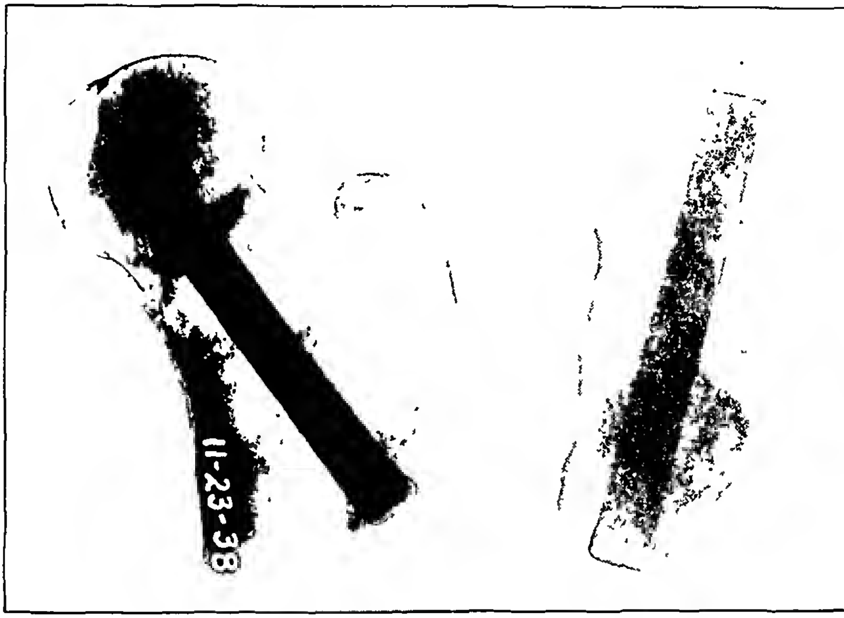

Fig. 2-A Fig. 2-B

Roentgenograms of anteroposterior and lateral views of the postmortem specimen.

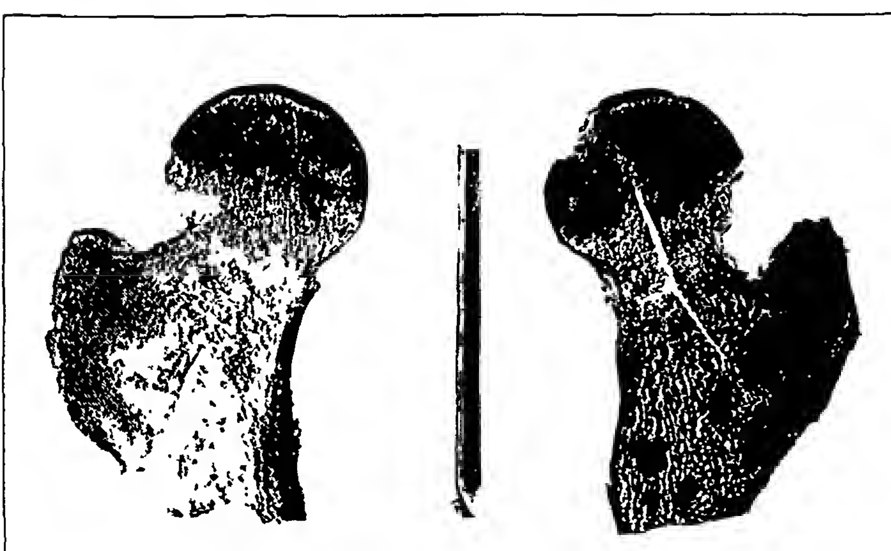

Fig. 3

Photograph of postmortem specimen divided in frontal section. The Smith-Petersen nail is shown between the halves of the specimen.

Microscopic Examination

By the use of a celloidin technique one-piece histological sections were made of the entire specimen. These sections were mounted on lantern-slide-size plates.

Fracture Site

The most outstanding feature of the fracture site was the presence of a multitude of fine-caliber, short, narrow, smooth trabeculae, more than half of which were still in the osteoid stage. Osteoclasts were conspicuous for their paucity. A moderate number of small osteoblasts were attached to the surfaces of some of the trabeculae. Most trabeculae appeared to have formed on the basis of fibrous tissue. These small young trabeculae were aligned in all directions, with no respect for static lines of stress. A few large mature bony trabeculae were also present in the fracture zone. Many of these trabeculae were dead, presumably as a result of separation from their blood supply at the time of the fracture. New bone was applied to the surfaces of numerous old trabeculae at and adjacent to the fracture site. A considerable degree of hyperaemia existed in the vessels of the fibrous marrow in this region. Marrow fibrosis was sharply limited to a zone approximately one-quarter inch wide at the fracture level (Fig. 4). Beyond this zone the marrow appeared quite normal. Not a solitary field of cartilage in any form could be found at the fracture site. The healing process appeared to consist simply of the formation of osteoid and bony trabeculae on the basis of reactive fibrous tissue which developed between the fragments and in adjacent marrow spaces.

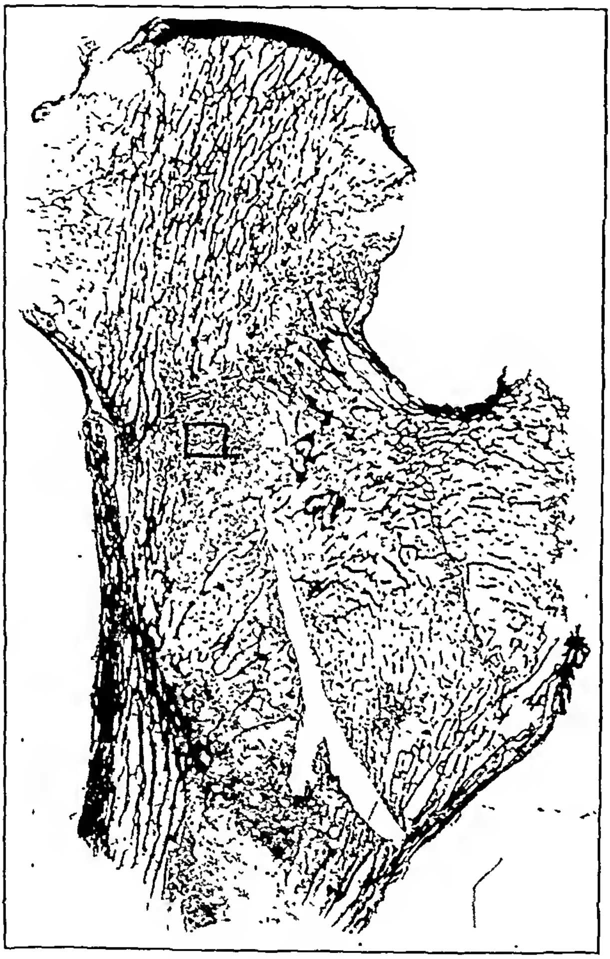

FIG. 4

Photograph of a histological section of the entire specimen. (See photomicrograh, Fig. 5.)

Femoral Head

Vascularity of the femoral head was not interrupted by the fracture, since very few necrotic trabeculae could be found beyond the immediate vicinity of the fracture. Several interruptions existed in the articular cortex as a result of reactivation of endochondral ossification. The zone of provisory calcification had proliferated to a considerably increased width and was being invaded at a few points with new bone which was applied to the margins of the small inroads. A few subjacent intratrabecular islands of calcified cartilage further testified to the beginning reactivation of endochondral ossification such as is observed in degenerative arthritis. The articular cartilage was of normal thickness and had a smooth gliding layer. Deeper layers showed a tendency toward basophilic staining, together with numerous Weichselbaum's lacunae containing several chondrocytes.

Neck and Trochanter

The neck and trochanteric regions revealed a good blood supply with viable trabeculae and marrow. The periosteum was interrupted and moderately thickened at the

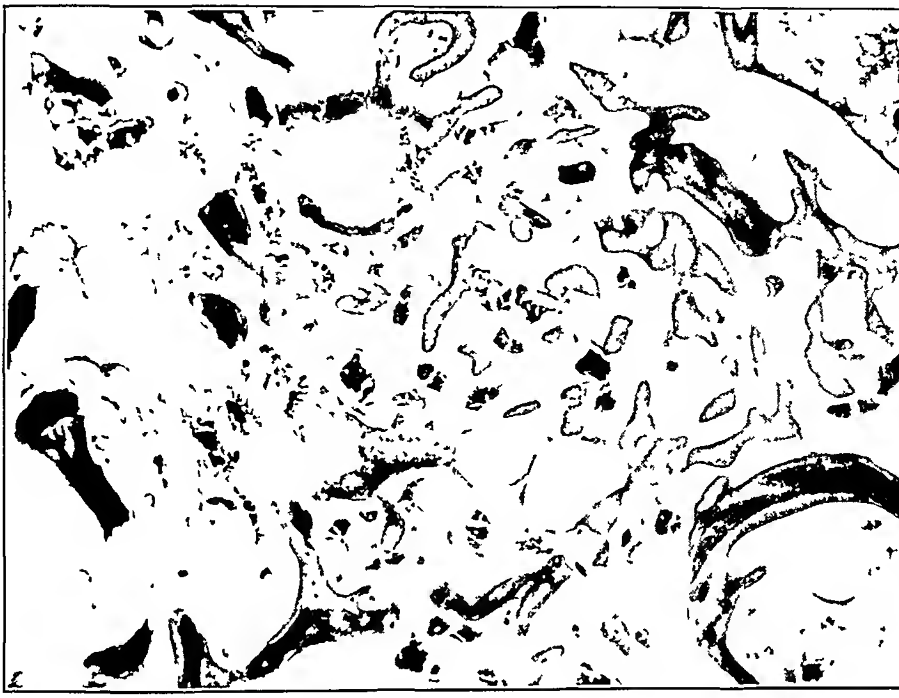

FIG 5

Photomicrograph of the section of the fracture site shown in the square in Fig 4

FIG. 6

Photomicrograph of a section of bone adjacent to a flange of the Smith-Petersen nail, showing the thin layer of fibrous tissue which formed as a minimal reaction to the nail

fracture site. On the inferior surface of the neck a thin bridge of fibrous tissue spanned the break in the periosteum. No subperiosteal new-bone formation was noted. Most bony trabeculae of the specimen were bordered by a thin layer of newly apposed bone, evidently a result of the stimulus of early activity which came from good fixation of the fragments.

Reaction Around the Stainless Steel Pin (Fig. 6)

The surfaces bordering the flanges of the nail were smooth and were covered by a layer of rather cellular fibrous tissue of microscopic thickness. Beneath this layer in some fields there was a tendency for subjacent bony trabeculae to combine to form a lamellar plate. In most fields there was no response whatever beneath the fibrous layer. A few chopped-off or fragmented trabeculae were seen and some of these were necrotic. There was surprisingly little evidence of trauma inflicted by the insertion of the pin. No inflammatory cells were found anywhere in the specimen.

CONCLUSIONS

The several features which are outstanding on the basis of our microscopic examination are:

1. The simplicity of and the rapid progress made by the healing process.
2. The absence of cartilage from the healing process at the fracture site.
3. The absence of subperiosteal reaction or peripheral callus.
4. The minimal evidence of trauma inflicted by the insertion of the pin.
5. The minimal reaction of the tissues to the presence of the pin.
6. The absence of significant osteoporosis, and the apposition of new bone on trabecular surfaces at such an early period after fracture.

It is quite clear from a study of our specimen that any method of internal fixation which meets mechanical requirements—such as good reduction, elimination of shearing stress at the fracture site, and adequate fixation of fragments *which are and remain in an excellent state of nutrition*—will result in bony union much sooner than has been generally appreciated in the past. These fundamentals should be borne in mind, since the prominence of technical detail has tended to subordinate some basic pathological and clinical aspects of the problem as a whole.

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GROWTH OF THE EPIPHYSES

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It is now generally accepted that growth of the diaphysis takes place at the cartilage columns in the epiphyseal plate, and that certain growth cartilages contribute more than others to longitudinal growth.[2, 13, 19] Proof of these facts was in part due to the proper interpretation of transverse lines observed in long bones following the clinical and experimental administration of phosphorus.[22, 29] The pathology of these transverse opacities was speculative until 1927, when Eliot[6] demonstrated that they were the result of a bony lattice work, produced by the enlargement and cross branching of the trabeculae, which at times illustrated even transverse bridging. The increased mass of bone at these areas presents a greater obstruction to roentgen rays than the normally trabeculated bone, resulting in the appearance of a line in the roentgenograms. Lines have been observed also in cases of congenital syphilis, in severe illness (particularly scarlet fever), in lead poisoning, and after ingestion of certain drugs. Microscopic section of teeth has demonstrated concomitant formation of lines as new enamel is added.[25]

In cases where phosphorus has been administrated intermittently, multiple lines have been observed. By measurement of the distances of these lines from their respective epiphyses, the amount of growth occurring in one portion of a bone can be compared with the growth of other parts of the same or other bones. The careful study and measurement of the lines as they appear in the *diaphyses* of *long* bones has added to our knowledge of bone growth by clinical corroboration of experimental work. They not only show the relative amount of growth taking place at the ends of long bones, but also prove

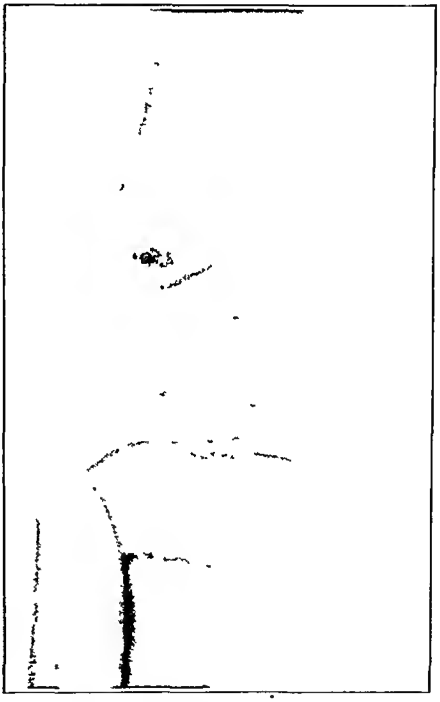


FIG. 1

Roentgenogram shows radiopaque lines in the diaphyses of the femur, tibia, and fibula of a child who received phosphorized cod-liver oil some time before. Growth at the distal end of the femur is greater than at the proximal ends of the tibia and fibula. The lines in the epiphyses proper are notable.

beyond doubt that shaft growth is the result of activity on the diaphyseal side of the epiphyseal cartilage.

Scant attention has been given the subject of growth of the epiphyses.

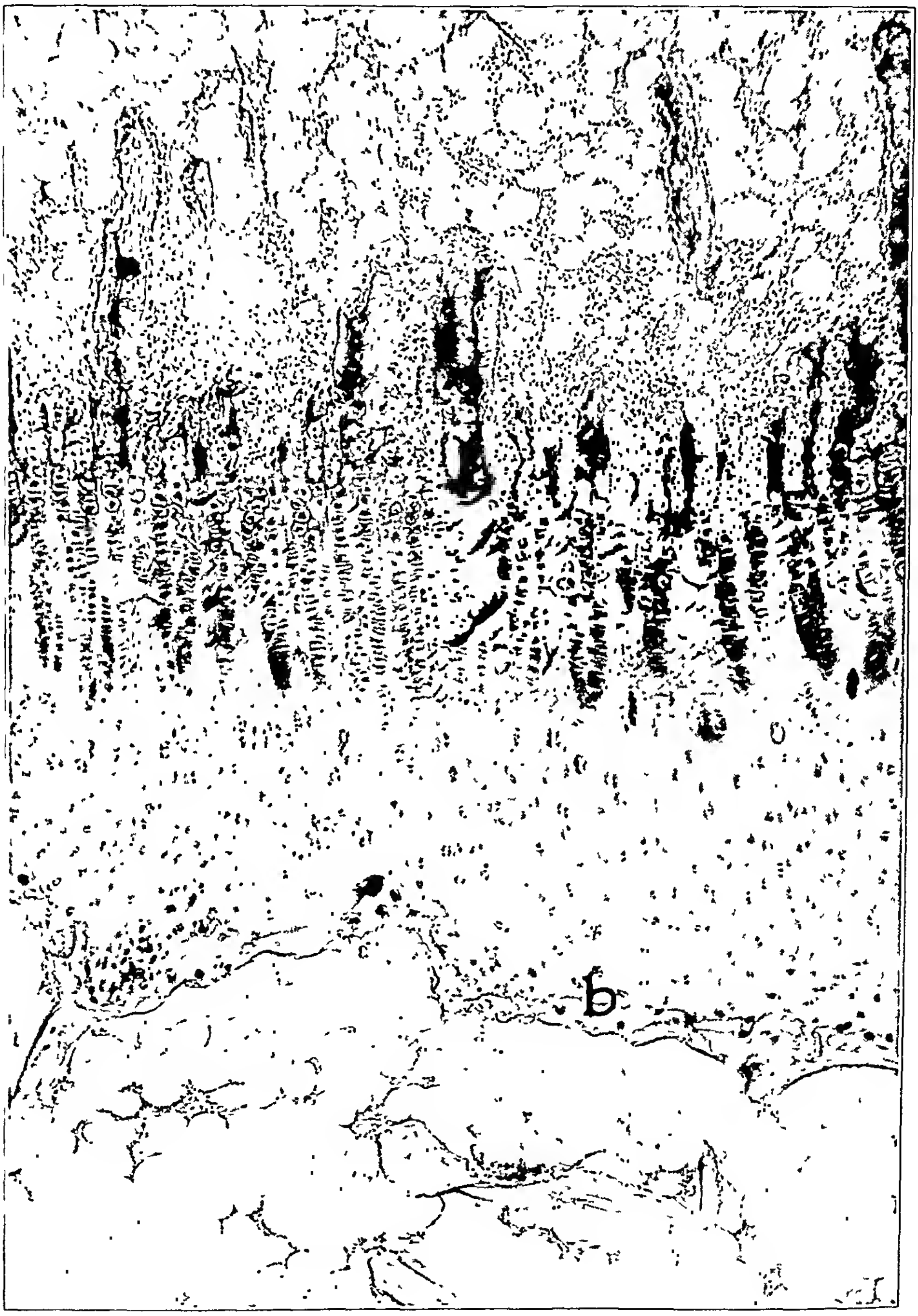


FIG. 2

Photomicrograph (×65) of epiphyseal cartilage.
a: Columns of cartilage streaming into the diaphysis. Active endochondra ossification is taking place. Shaft growth is localized here.
b: Epiphyseal side of the epiphyseal cartilage shows no evidence of active endochondral ossification.

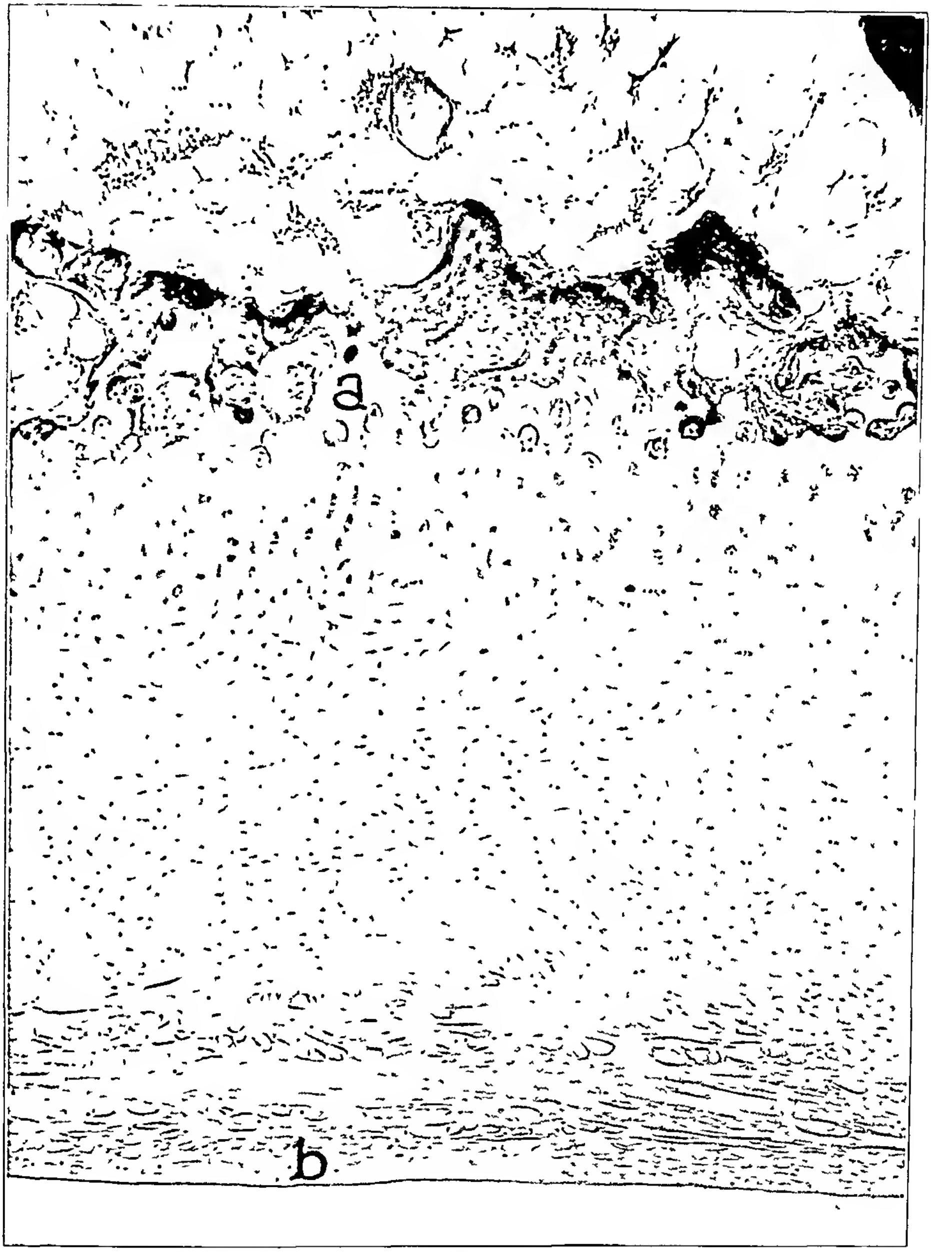


Fig. 3

Photomicrograph (×65) of cross section of articular cartilage.
a: Juxta-epiphyseal side of articular cartilage. Note rather active endochondral ossification.
b: Articular surface.

Available information is largely contradictory and poorly substantiated, and there is no consensus concerning growth of the epiphysis itself.[1, 3, 8, 16]

Our attention has been attracted for some time to the appearance of lines in the epiphyses of children as a result of disease or phosphorized cod-liver-oil medication (Fig. 1). Since interpretation of the radiopaque lines in the diaphyses has thrown light on shaft growth, it was thought

Fig. 4

Roentgenogram of pelvis of the child in Fig. 1. Note how the phosphorous line (*a*) conforms to the curve of the epiphysis of the crest of the ilium. The angled radio-paque line (*b*) illustrates that growth at the proximal end of the femur is the result of two forces, the capital and trochanteric epiphyseal growth centers, which at this time actually act as one.

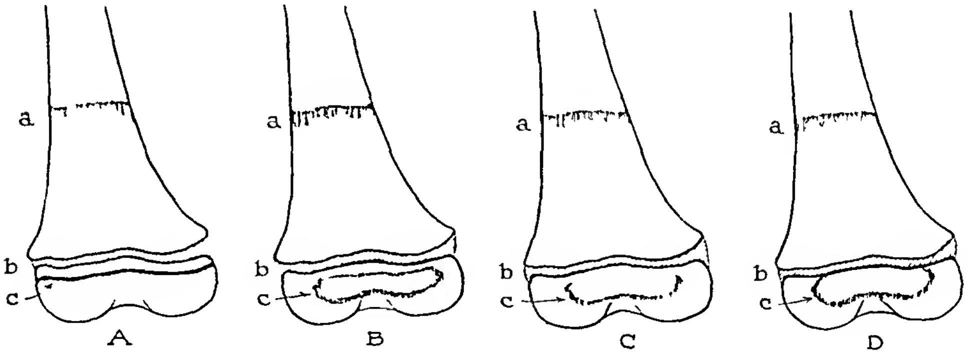


Fig. 5

Diagrams of the ends of four bones showing:
a: Growth line in shaft; *b:* Epiphyseal cartilage;
c: Hypothetical growth lines in epiphyses as discussed in text.

that study of similar lines occurring in epiphyses might clarify the question regarding their method of growth. We now believe that an interpretation of these lines presents very definite proof of how epiphyseal growth occurs.

As a background for the study of epiphyseal growth it is perhaps wise to consider the cellular structure and physiology of epiphyseal and articular cartilage, respectively, in cross section. The columns of cartilage (*a* in Fig. 2) streaming off into the diaphysis are readily seen. The

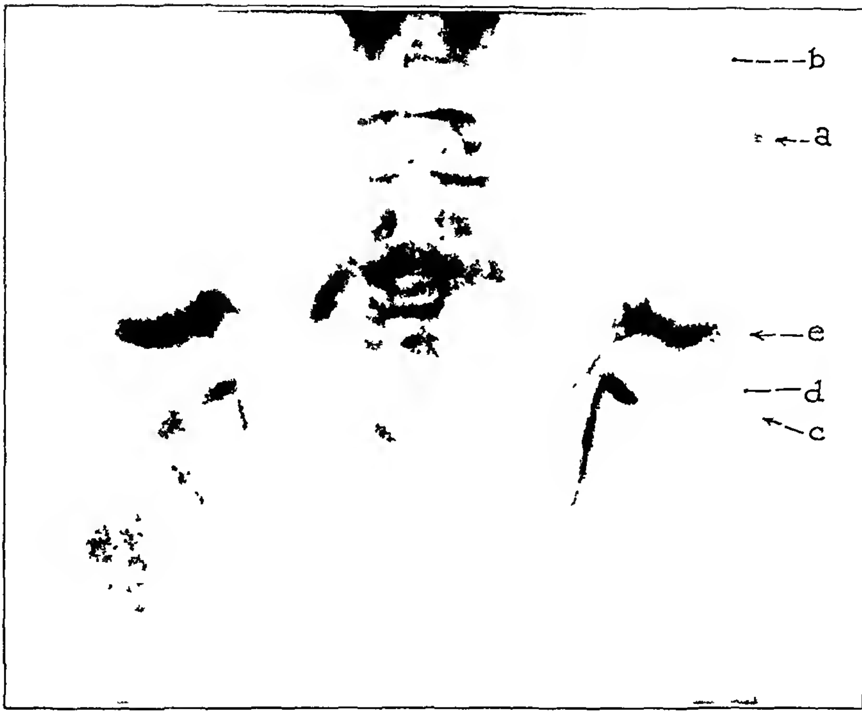


Fig. 6

Roentgenogram of pelvis of a girl with dyschondroplasia shows:
a: Wide phosphorous line; *b:* New bone added since cessation of medication, *c:* Line corresponding to *a*; *d.* New bone added after discontinuance of medication;
e: Line corresponding to *a* and *c*.

Fig. 7

Roentgenogram of same pelvis as Fig. 6, taken three years and four months later. Note increase in width of *b* and *d*. There is no translucent area in the region of the epiphyseal plate. The distance from *e* to the articular surface of the acetabulum is much increased.

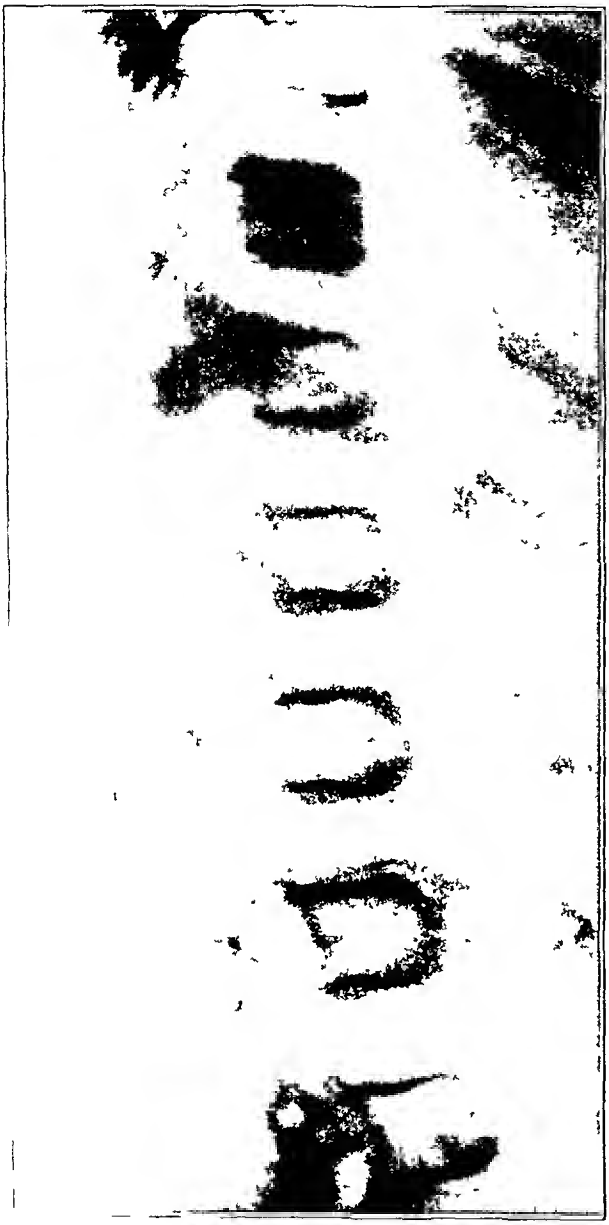


FIG. 8

Roentgenogiam shows phosphorous lines in vertebrae, and illustrates addition of new bone superiorly, inferiorly, and anteriorly.

experimental work of Haas[11, 12] has positively loealized this area as the souree of shaft growth. Careful study of the juxta-epiphyseal side of the epiphyseal cartilage (*b* in Fig. 2), however, fails to show any signs of endochondral ossifieation. On the other hand, serutiny of the juxta-epiphyseal side of the *articular* eartilage (*a* in Fig. 3) reveals definite signs of endochondral ossification, though to a lesser degree, of course, than on the shaft side of the epiphyseal cartilage. This is microscopic evidence that growth activity in the epiphysis is confincd to the articular cartilagc.

There has bcen considerable controversy about whether the youngest articular cartilage cells are those bathed by the synovial fluid or those nearest the bone. Ogston[18] believed "that articular eartilage is eonstantly renewing itself from a foeus of eentral growth, and grows in two directions". He believed that an effete layer was formed toward the joint, which was worn away by joint movements. Fisher[7] showed elearly that these "effete" cells, far from being degenerate, are the souree from which the deep eells are derived, and are analogous to the perichondral eells of eostal eartilage.

Epiphyseal and articular eartilages are normally avaseular[14] and present the typical mode of growth of a vegetative tissue. The experiments of von Tappeiner[26] demonstrated that in transplanting the radial head of one rabbit to another the cartilage usually lived while the bone became necrotic. This has been proved experimentally by others also. Clinically

the behavior of loose bodies within joints is analogous. In cases of osteochondritis dissecans it has been shown that the osseous components of the fragments necrose early, whereas the cartilage cells remain alive for varying periods of time. Bathed in synovial fluid their environmental and nutritional status remains essentially the same whether they are attached to the subchondral bone or free in the joint. They have even been observed to grow progressively larger by proliferation of fibrocartilage cells,[23] and they usually assume a more spherical shape. At times even the bony elements increase, so that the osseous nucleus becomes larger than the original bony particle. Thus, articular cartilage not only may live, but proliferate and undergo ossification without direct blood supply.

FIG. 9

Roentgenogram of proximal humeral epiphysis in the same child. Note that the ends of the semicircular line (*a*) extend down to the epiphyseal line.

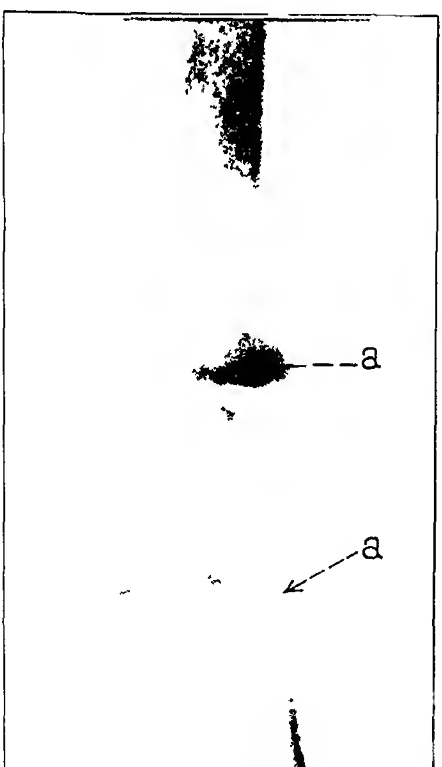


FIG. 10

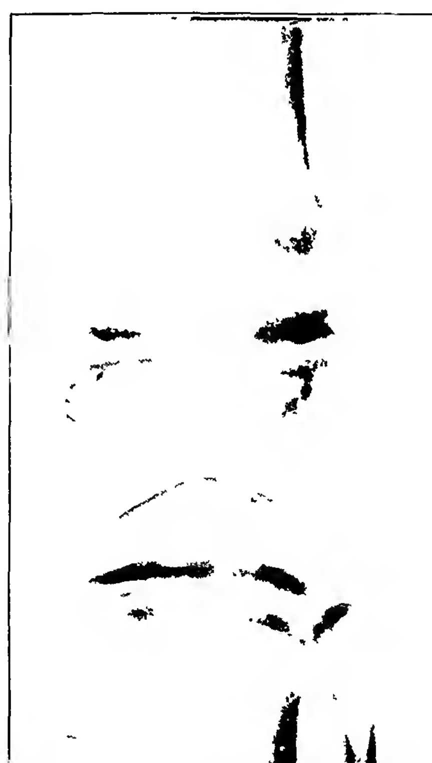


FIG. 11

Fig. 10: Roentgenogram of knee shows formation of phosphorous lines (*a*).
Fig. 11: Roentgenogram of the same knee as shown in Fig. 10 illustrates multiple lines as a result of intermittent phosphorized cod-liver-oil medication.

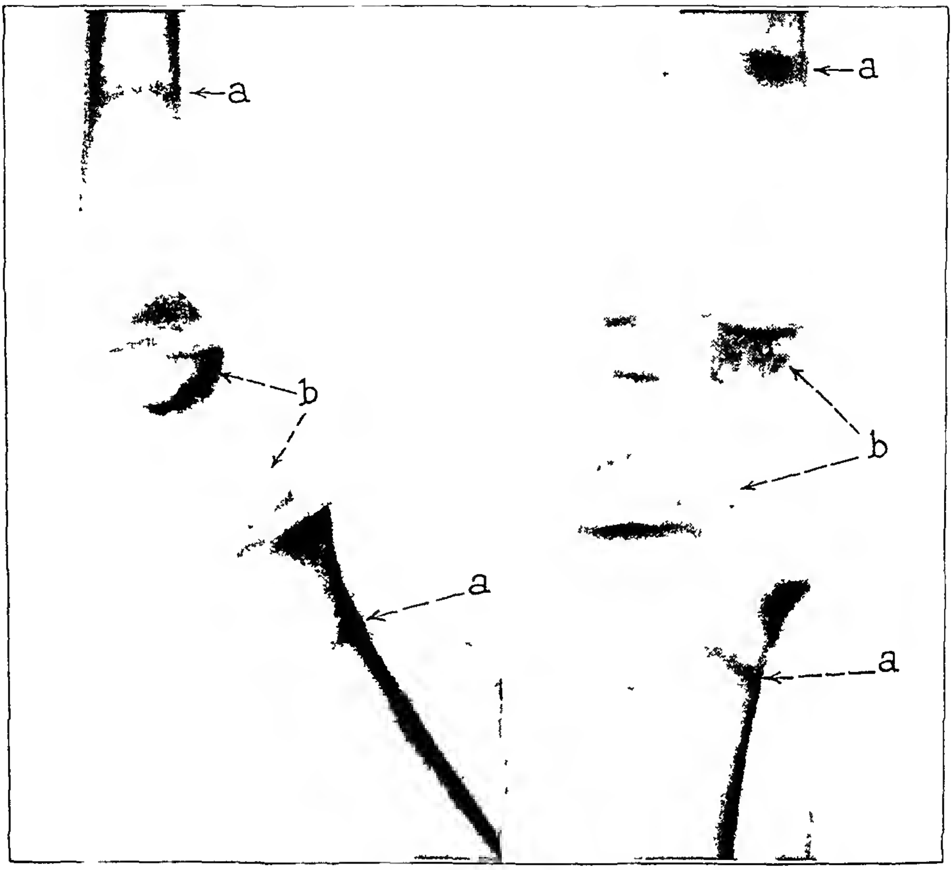


FIG. 12

Roentgenograms of the same knee as shown in Fig. 11 taken four years later. The lines (*a*) are much more distant from the epiphyseal lines and are fading. The limbs of the figures (*b*) within the epiphyses extend down to the epiphyseal lines.

With these points in mind, study of roentgenograms showing phosphorous lines is illuminating.

In the roentgenograms of children, radiopaque lines due to lead, bismuth, phosphorized cod-liver oil, etc., have been observed to assume very definite patterns.[4, 5, 20, 28] These patterns depend upon the method of growth of that particular epiphyseal cartilage. For example, note the opaque lines formed by the growth cartilages of the ilium and the proximal end of the femur in Figure 4. Study of these lines gives concrete evidence of the process of growth in each place.

Assuming that similar radiopaque lines would form in the epiphyses proper, we might expect to find one of four patterns, depending upon the localization of growth. Should the increment of growth contributory to the enlargement of the *epiphysis* take place solely from the epiphyseal plate, we might reasonably expect a line such as *c* in Figure 5-A. On the other hand, if growth of the epiphysis were equally divided between the epiphyseal and articular cartilages, we might conceivably find a pattern such as *c* in Figure 5-B. Should both areas contribute to growth and the transverse line fail to form, the appearance would be as shown in *c* of

Figure 5-C, in which the limbs of the figure fail to extend to the epiphyseal cartilage. If growth of the epiphysis were the result *solely* of the *articular* cartilage, we should find a pattern similar to *c* of Figure 5-D. Study of the roentgenograms of many cases showed only epiphyseal growth lines as illustrated by Figure 5-D.

In the pelvis of a girl with dyschondroplasia (Fig. 6) the broad lines (*a*) in the ilia represent a period of phosphorus therapy. The more transparent bone (*b*) has been added since discontinuance of the medication. The capital femoral epiphyses show a semilunar line (*c*) which corresponds to the lines observed in the ilia. The peripheral, less opaque area (*d*) is comparable to *b*. Three years and four months later (Fig. 7) the wide bands in the ilia appear more centrally placed, due to addition of new bone by the growth cartilage of the iliac crests. The pattern within each capital femoral epiphysis is significant. The narrow, more radiotranslucent semicircle of bone on the periphery has become much wider because of endochondral growth and ossification from the articular cartilage. There is no evidence of new bone on the epiphyseal side of the epiphyseal plate.

The proximal humeral epiphysis (Fig. 9) of the same child shows a similar configuration. The limbs of the phosphorous line (*a*) extend down to the epiphyseal cartilage and new bone has been added peripherally.

Interpretation of lines observed within vertebrae (Fig. 8) leads to the conclusion that very little bone accrues posteriorly. Increase of size takes place principally in the other directions.

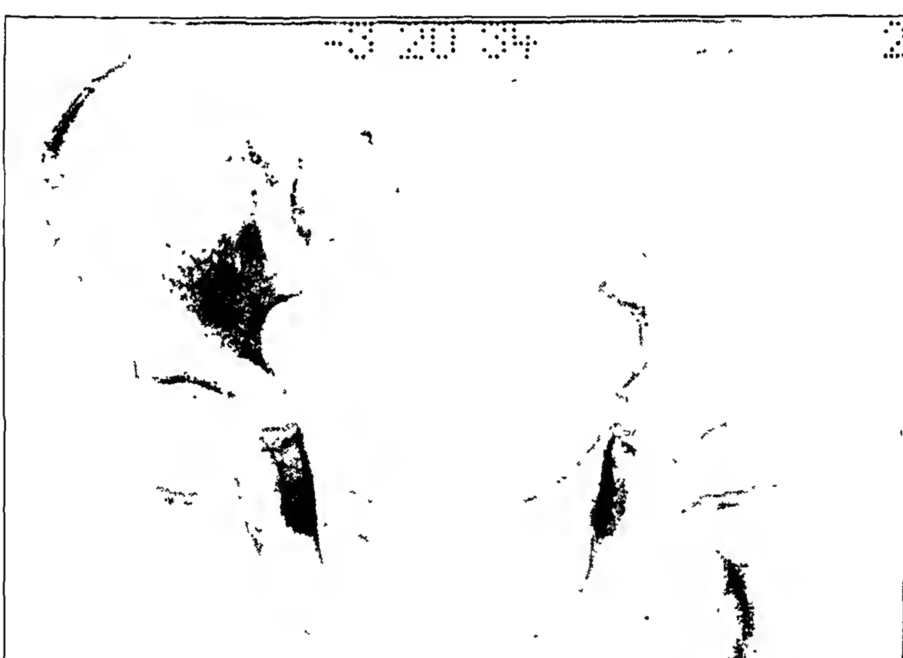


FIG. 13

March 20, 1934, Roentgenogram of same case as Figs. 10, 11, 12 shows phosphorous line forming at the crest of the ilium and roof of the acetabulum.

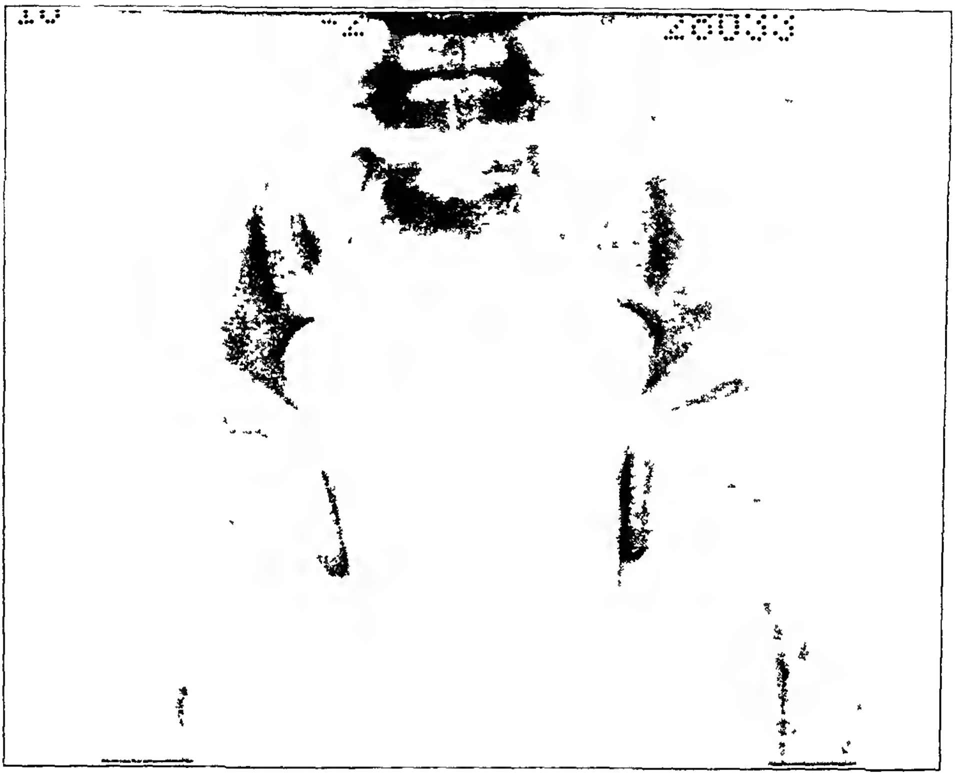


FIG. 14

Roentgenogram of same case shown in Fig. 13, taken three years later. The lines within the capital epiphyses are faint, but can be seen to extend to the epiphyseal line. New bone has been added at the superior portion of the acetabulum and crests of the ilia, causing the phosphorous lines to appear more centrally placed.

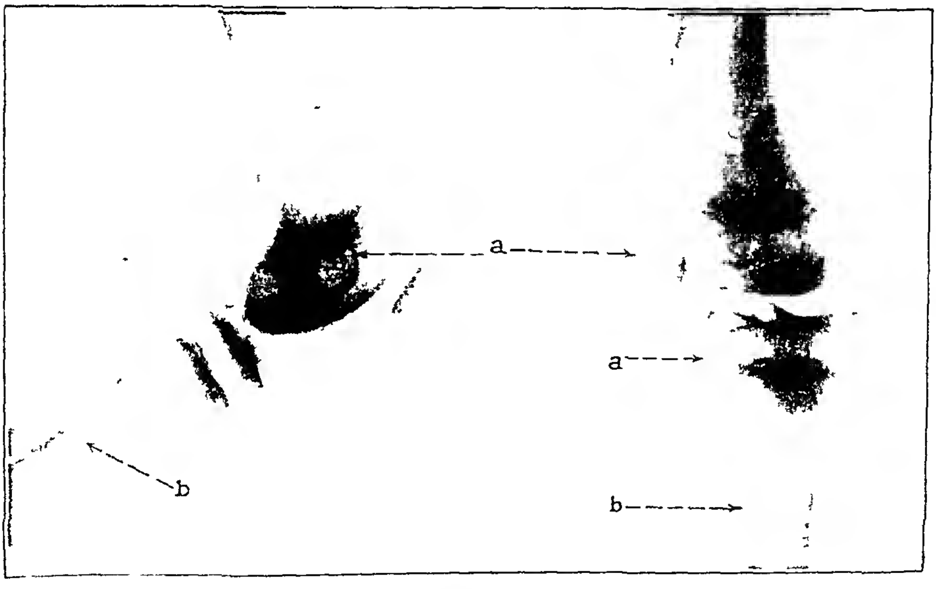


FIG. 15

Roentgenograms of knees show the limbs of the epiphyseal figures (*a*) extending to the epiphyseal lines. New bone seems to have been added to the epiphysis everywhere except at the epiphyseal cartilage. Fading transverse lines (*b*) are seen in the tibiae. Corresponding lines have presumably already faded from the femora.

Figure 10 shows the formation of phosphorous lines (*a*) during administration of phosphorized cod-liver oil. The medication has been discontinued and resumed at intervals, causing the formation of multiple lines (Fig. 11) which progressively become more distant from the epiphyseal line as new bone is added. Four years later (Fig. 12) the transverse lines (*a*) in the diaphysis are still farther away from the epiphyseal line and are fading. The limbs of the lines (*b*) in the epiphyses extend to the epiphyseal lines and new bone has been added by growth and ossification from the articular cartilage. Figures 13 and 14 illustrate well the growth of the epiphyses about the pelvis in the same case over a period of three years.

The lines (*a*) of Figure 15 are probably the result of disease. The limbs of the figures within the epiphyses extend down to the epiphyseal plate. New epiphyseal bone has been added by articular cartilage only. The remains of transverse lines (*b*) are seen in the tibiae, but have completely faded from the femoral shafts. This child did not have phosphorized cod-liver oil. The etiological factor was probably a mild case of scarlet fever five years earlier.

Intermittent administration of phosphorized cod-liver oil has caused the formation of multiple lines in Figure 16. Four years later (Fig. 17) the multiple lines in the shaft have almost disappeared. The limbs of the figures within the epiphyses extend to the epiphyseal cartilage plate.

Roentgenograms of knees of growing children which had been surgically fused were next studied. In these cases the articular cartilage of tibia and femur had been removed and fusion of the bony centers of the epiphyses had occurred.

In view of the findings observed in the previously described roentgenograms, it was postulated that with removal of the *articular cartilage* and fusion of osseous elements of the adjacent epiphyses of femur and tibia, the epiphyseal

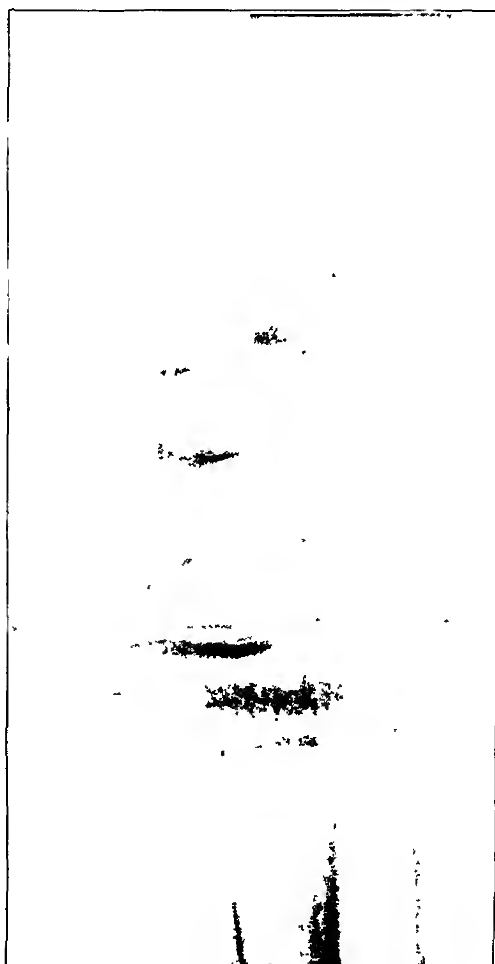


Fig. 16

Roentgenogram illustrates transverse diaphyseal lines due to interrupted medication. Note the lines within the epiphyses.

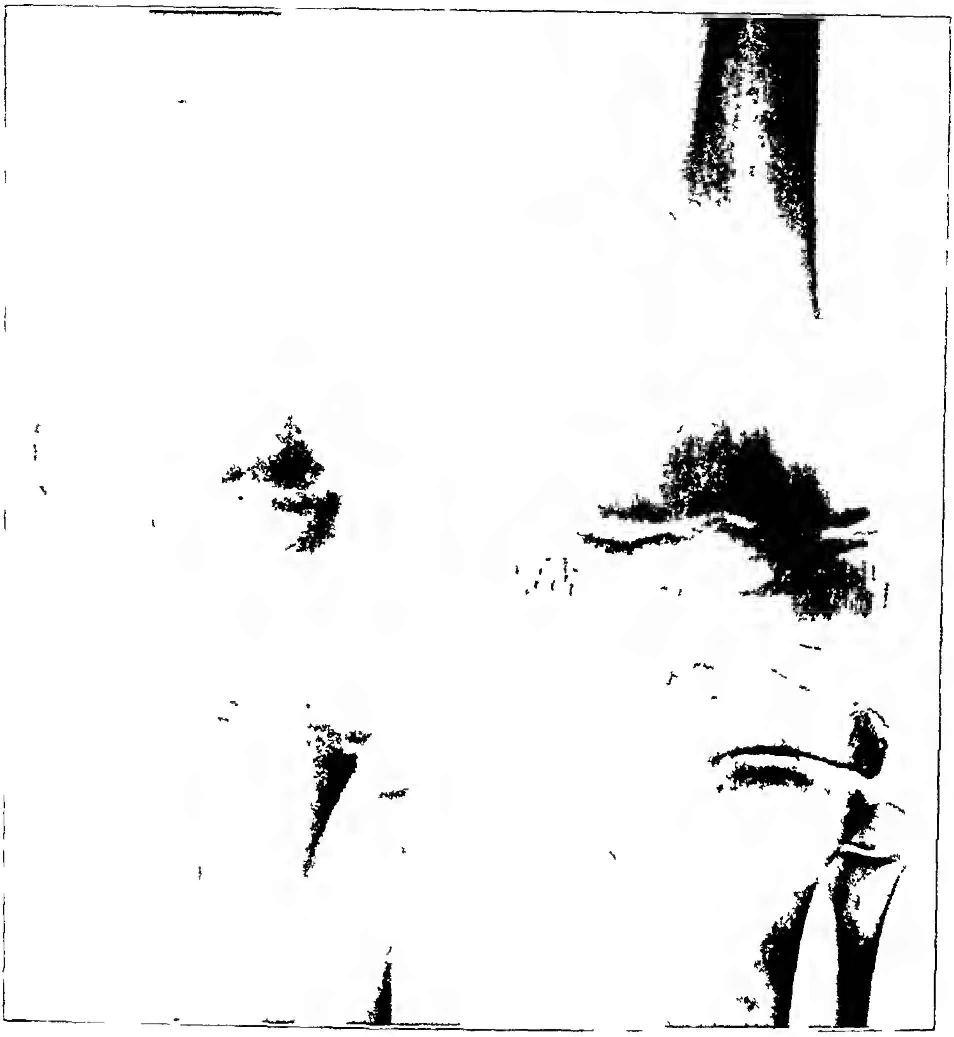
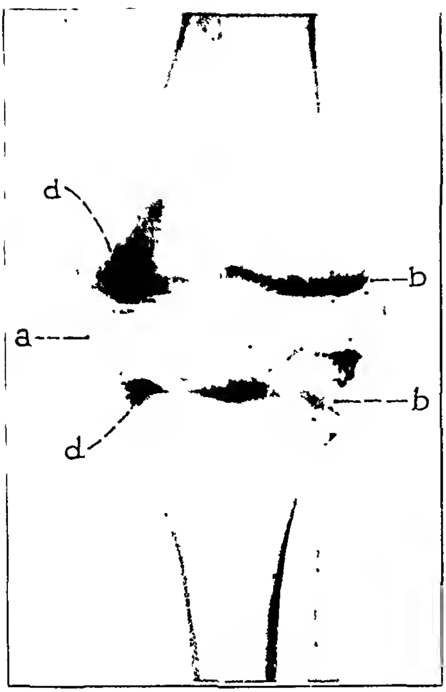


FIG. 17

Roentgenogram of same case as shown in Fig. 16. The diaphyseal lines have faded, but the lines within the epiphyses form a characteristic figure in which the limbs extend to the epiphyseal line, which is evidence against growth having taken place on the epiphyseal side of the growth cartilage.

cartilage plates should not grow farther apart. In other words, the vertical diameter of the combined epiphyseal nucleus should not increase. Figure 18 is representative of this group. The two epiphyses have formed one bony block (*a*) between the epiphyseal cartilages (*b*) of the tibia and femur. New phosphorous lines (*d*) are being produced.

Three years and four months later (Fig. 19), there has been a marked increment in shaft growth. The lines (*d*) of Figure 18 are now represented by (*d*) of Figure 19. The vertical diameter of the combined epiphyseal block has not increased. This is confirming evidence that articular cartilage is necessary for longitudinal growth of the epiphyses and that the epiphyseal cartilage has not contributed in any appreciable degree to the size of the combined epiphyses



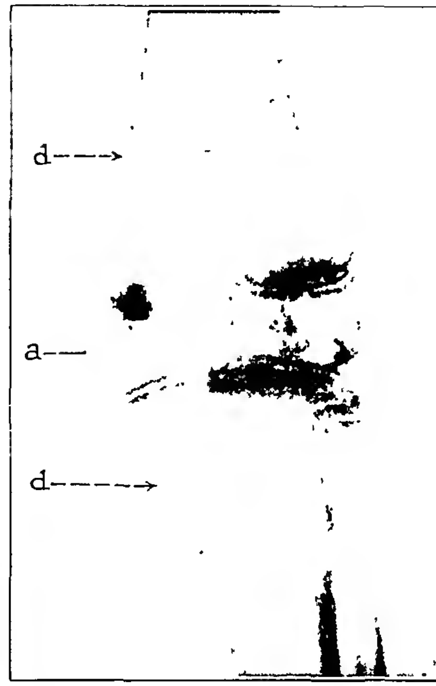


FIG. 18 FIG. 19

Fig. 18: Roentgenogram of a surgically fused knee.
a: Combined epiphyseal block; *b:* Epiphyseal cartilage; *d:* Early phosphorous line.

Fig. 19: Roentgenogram of same knee taken three years and four months later. Diaphyseal growth has been active. Early phosphorous lines (*d* of Fig. 18) are now represented by lines *d*. The vertical diameter of the combined fused epiphyses (*a*) is not increased.

CONCLUSIONS

1. Growth of the epiphysis takes place by proliferation of the articular cartilage followed by endochondral ossification.

2. The epiphyseal cartilage is a negligible factor in longitudinal growth of the epiphysis, if it contributes at all.

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PSEUDO-PLATYBASIA: RUPTURE OF THE TRANSVERSE LIGAMENT OF THE AXIS WITH DISPLACEMENT OF THE ODONTOID PROCESS AND COMPRESSION OF THE CERVICAL CORD

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INTRODUCTION

Chamberlain [1], List [3], and Schüller [5] have recently called attention to a condition known as platybasia, or basilar impression, which has long been recorded in the German literature but little discussed by American clinicians.

Platybasia is a deformity of the occipital bone and the upper end of the cervical spine, variously attributed to rickets, osteitis deformans, osteomalacia, long-standing, increased intracranial pressure, or developmental anomaly. Schüller states that traumatic "basilar impression" has no practical importance inasmuch as such cases are nearly always fatal. Trauma to the head and neck may be of considerable importance, however, in influencing the progression of the disease, whatever the primary etiological factors are. Thus it is of some interest that platybasia is more frequent in countries where it is the custom to carry all burdens on the head [5].

Platybasia is characterized by an upward displacement of the clivus and a narrowing of the foramen occipitale magnum so that the medulla and the cervical cord are subjected to varying degrees of compression. The clinical picture is variable but often simulates disseminated sclerosis, syringomyelia, cerebellar tumor, or progressive spastic paralysis, depending upon the sites of pressure. X-ray examination of the occipital region reveals characteristic changes. Surgical intervention may lead to dramatic recovery.

We have recently had the opportunity to examine at postmortem a patient in whom the condition of platybasia was closely simulated as the result of trauma sustained thirty years previously. The case is of particular interest in that the patient was able to survive with a minimal amount of permanent damage to the nervous system in spite of an extremely acute onset of symptoms.

CASE HISTORY

The patient, a forty-five-year-old Italian-born female, was admitted to the New York Hospital for the second time on April 6, 1940. Her chief complaint was shortness of breath and swelling of the ankles and abdomen for the previous four or five months.

At the age of sixteen the patient fell on her head. She was unconscious for "some time" and was "paralyzed on both sides" for the following nine months. She had a

"crooked neck" following the injury, and was said to have had lameness, weakness, and an unusual gait, all of which persisted up to the time of her death. A tonsillectomy was performed at the age of thirty-four years for recurrent sore throat.

At the time of her first admission to the hospital, in 1935, the patient complained of weakness on the right side. The patient had a brief, transient fainting spell on two occasions two days before admission. The following day she had a severe headache associated with progressive weakness and numbness of the right extremities, and some drowsiness.

On physical examination the patient was stuporous and dull, but could be aroused. A short coarse presystolic murmur was heard over the apex of the heart. There was accentuation of the first mitral and second pulmonic sounds. The heart rate was regular but rapid (110). The blood pressure was 100/80. Râles were present at both lung bases. The liver and spleen were not felt. No petechiae were present.

Fig. 1

Plaster cast of foramen magnum shows the narrowing of the passageway for the cervical cord.

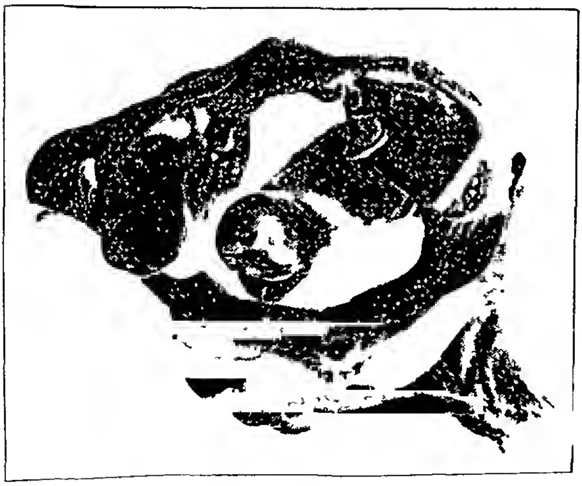

Fig. 2

An atlas and an axis placed in the same relative positions as occupied by those of the patient.

Neurological examination revealed a stiff neck, a Brudzinski sign on the left, absent corneal reflex on the right, a smooth face on the right with drooping of the corner of the mouth on that side, hyperactive biceps and triceps tendon jerks on both sides, slight spasticity of the right arm with increased resistance to stretch and little or no voluntary motion, absent abdominal reflexes, hyperactive knee and ankle tendon jerks, marked bilateral patellar and ankle clonus, bilateral Babinski sign, diminished sensibility to pain in both lower extremities, loss of voluntary motion of the right lower extremity, and incontinence of both urine and faeces.

The white blood count gradually decreased from 15,600 on admission to 6,000 one month later. The temperature fell by lysis from 39.8 degrees centigrade to within normal limits two weeks later. A lumbar tap at the time of admission revealed the resting spinal fluid pressure to be 140 millimeters of water. The fluid was grossly bloody but upon centrifugation the supernatant fluid was clear. There were five lymphocytes and one polymorphonuclear leukocyte per cubic millimeter. The sugar and chloride contents were eighty and 680 milligrams per 100 cubic centimeters respectively. The Wassermann was negative.

There was gradual improvement in the patient's condition during the following two months. The weakness on the right side had not completely disappeared, however, and the patient continued to have hyperactive tendon jerks, absent abdominal reflexes, bilateral patellar and ankle clonus, and a bilateral Babinski sign. The patient was removed to her home for chronic care.

Following discharge the patient improved and was again able to be up and about, with little more disability than she had experienced prior to the recent acute episode.

Four or five months before the second admission the patient noted increasing "weakness", dyspnoea on exertion, orthopnoea, swelling of the ankles and legs late in the day, and migratory pains. These symptoms became progressively worse until the patient was completely incapacitated.

On physical examination her temperature was 37 degrees centigrade; pulse, 100; respirations, thirty-six; blood pressure, 190/140. The patient then appeared thin, emaciated, acutely and chronically ill. She was markedly orthopneic, dyspneic, and cyanotic. The cardiac signs were much the same as described on the previous admission. Distended neck veins, moist râles in the lungs, ascites, hepatomegalia, and massive oedema of the lower extremities were present. The patient's condition prevented an adequate neurological examination, but it was noted that the tendon jerks were hyperactive and the abdominal reflexes were absent.

With treatment by digitalis and mercupurin the patient's general condition improved markedly, and there was a fall of the blood pressure to more nearly normal ranges. In spite of this apparent clinical improvement, the patient died quietly on the fourteenth hospital day.

POSTMORTEM EXAMINATION

Gross Examination

There was chronic endocarditis of the mitral valve with stenosis and insufficiency. Dilatation and hypertrophy of both auricles and of the right ventricle were present. The lungs, liver, and kidneys showed the characteristic changes of chronic passive congestion. There was oedema of the lower extremities; ascites (200 cubic centimeters); and a bilateral pleural effusion (300 and 500 cubic centimeters). Old healed infarcts were present in the spleen and kidneys.

Upon opening the cranial vault there appeared to be an increased amount of subarachnoid fluid. As the brain was elevated from the floor of the cranium a

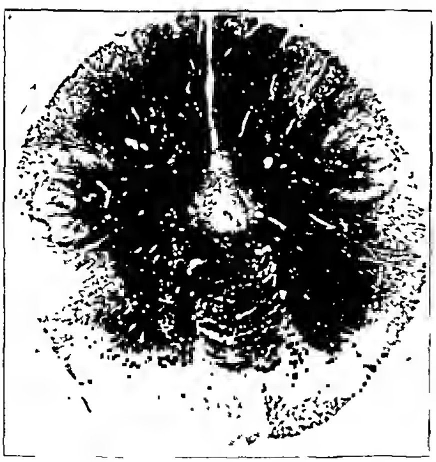

FIG. 3

A section taken through the medulla, stained for myelin sheaths.

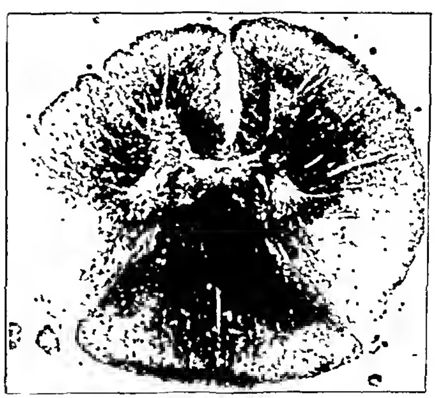

FIG. 4

A section taken through the dorsal region of the spinal cord, stained for myelin sheaths.

Fig. 5
Postmortem roentgenogram of skull showing the left lateral view.

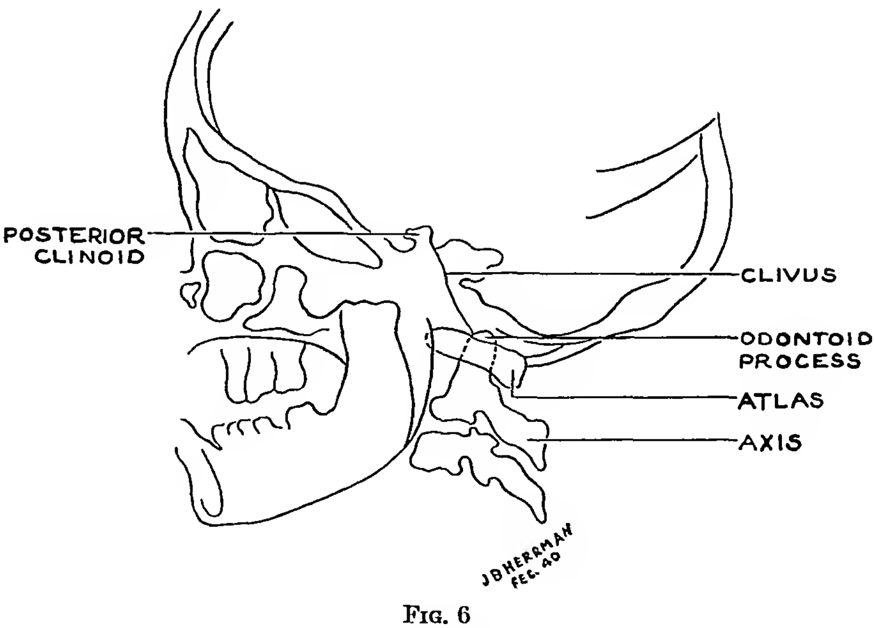

Fig. 6
Diagrammatic interpretation of Fig. 5.

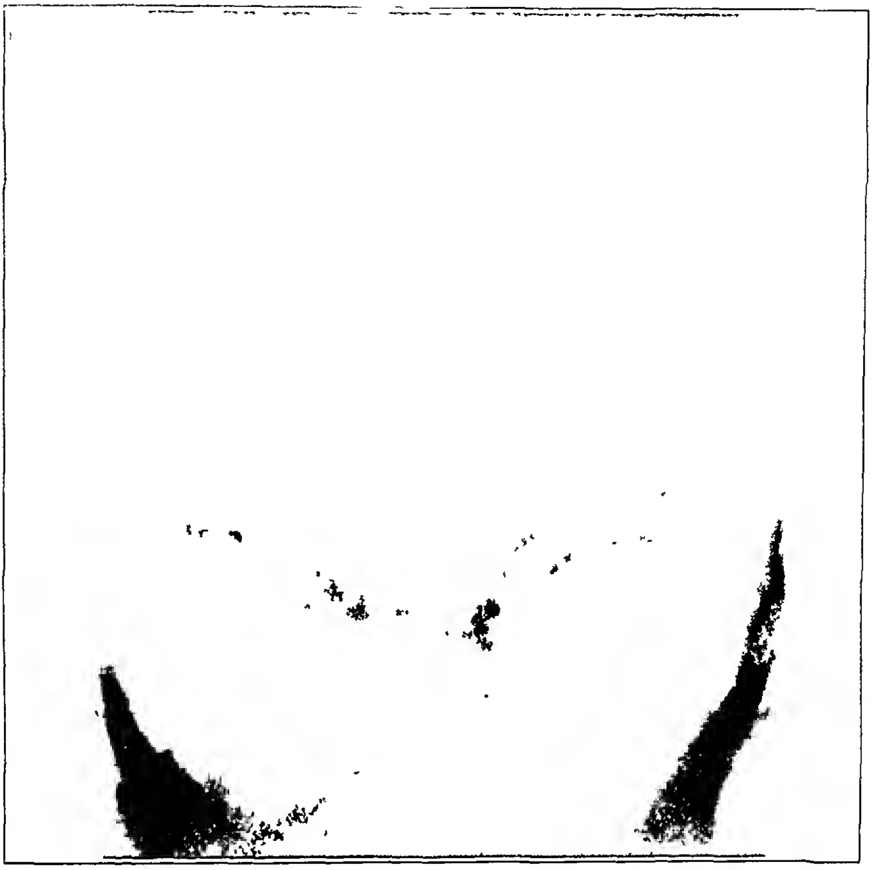

FIG. 7
Postmortem roentgenogram of skull showing anteroposterior view.

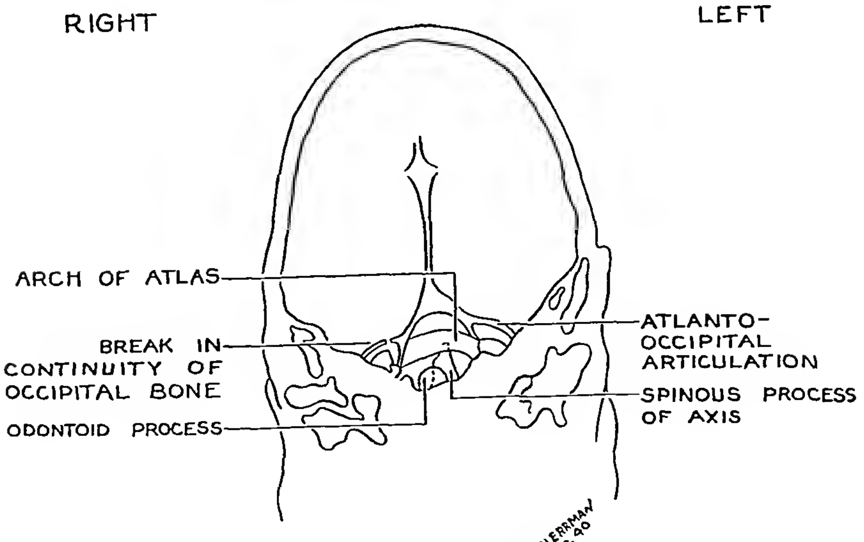

FIG. 8
Diagrammatic interpretation of Fig. 7.

deformity of the clivus and of the foramen occipitale magnum became apparent. The clivus was flattened and elevated posteriorly on the left, so that the usual downward and backward slope of 60 degrees was replaced by a slope of approximately 30 degrees. There was also a slope downward and to the right in the transverse planes. The cervical cord passed through a small slitlike space located along the right lateral border of the foramen occipitale magnum. The cord appeared to be compressed. The remainder of the foramen occipitale magnum was obliterated by what was first interpreted as a bony exostosis from the margin of the foramen and the basilar portion of the occipital bone (Fig. 1). It was thought at this point that we were dealing with a platybasia, but removal of the dura from the base of the skull revealed that this was not the case.

The foramen ovale was normal in outline but protruding up into the foramen, and pushing the dura before it so as to form a false base, was the dens of the epistropheus. Removal of a portion of the clivus gave a better view of the upper cervical vertebrae. Figure 2 illustrates the relative positions of the atlas and axis. The backward and lateral displacement of the odontoid process is apparent. This picture does not show, however, several other important facts learned from roentgenographic examination of the region, and manipulations at the time of the postmortem examination. The skull was tilted to the right and there was limitation of motion with respect to the atlas but not with respect to the remainder of the cervical spine. The postmortem roentgenograms (Figs. 5 and 7) were interpreted by John R. Carty, M.D., as follows:

"Postmortem films of the base of the skull and the upper cervical region show a slight tilting of the skull on the cervical spine to the right. The atlanto-occipital articulation on the right is narrowed and there is a break in continuity of the basal occipital bone in the immediate neighborhood. This does not extend into the bone to any extent. The atlanto-occipital joint on the left is wider than usual. There has been a crushing of the right half of the body of the atlas, with apparently some separation of the fragments. This has permitted the backward and left displacement of the odontoid process. I cannot determine definitely whether or not it has been fractured also. The findings do not suggest platybasia but seem typical of an old injury."

Examination of the brain revealed a moderate cortical atrophy with some thickening of the pia-arachnoid. In the anterior portion of the left internal capsule and in the putamen was an anaemic infarct. An early internal hydrocephalus was present.

Microscopic Examination

On microscopic examination, the lesion of the internal capsule and putamen consisted of fibrous tissue in which were many focal accumulations of gitter cells. Sections through the mid-olivary region of the medulla stained for myelin sheaths showed a marked degeneration of the pyramidal tract on the left side. The medial lemniscus and the inferior cerebellar peduncle appeared to be normally myelinated. At a slightly lower level in the medulla degenerative changes in the dorsal spinocerebellar tracts, especially on the left side, were present (Fig. 3). Sections through the thoracic portion of the spinal cord revealed a marked degeneration in both crossed pyramidal tracts, and slight degeneration in the anterolateral portions of the white matter. These changes were most marked on the left side of the cord (Fig. 4).

DISCUSSION

Unfortunately we did not have the opportunity to study this patient when her signs and symptoms referable to the cord injury were not complicated by other lesions. The neurological findings during convalescence from the lesion in the left internal capsule and the degenerative changes found at autopsy in the tracts of the cord prove, however, that the patient did have persistent bilateral pyramidal-tract lesions attributable to the injury sustained thirty years before her death. It is of interest

that the degenerative changes in the pyramidal tracts below the site of compression were greatest on the left side, even though the infarct was in the left internal capsule. The left side of the cord was in nearest proximity to the odontoid process.

Fracture of the atlas is relatively infrequent[4], but, contrary to lay opinion, is not associated with a particularly high mortality[2]. Fracture of the odontoid process, however, is characterized by a very high mortality[6]. Indeed, this is the mechanism of death by hanging. The odontoid process is held in position by a strong transverse ligament posterior to it, and it is quite unusual for the normal anatomical relation between it and the adjacent structures to be disturbed. We have no detailed information concerning the trauma in the case presented, but must necessarily assume that it was extremely severe in order to tear this transverse ligament.

The author wishes to express his sincere thanks to Drs. Bronson Ray, Lewis Stevenson, John R. Carty, and Charles Reavis for their assistance in the study of this case.

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ANICS OF THE LIGAMENTS AND MENISCI OF THE KNEE JOINT

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There is a vast amount of literature available discussing the movements of the knee joint and the function of the ligaments controlling these movements. A comprehensive review of the literature reveals no unanimity of opinion concerning the function of the knee-joint ligaments, and often equivocal statements are made. A study of the literature on this subject leaves one bewildered. Accordingly, a reinvestigation of the subject was made.

Fick [18] published an excellent discussion of all aspects of the knee joint. His work is highly recommended because of its thoroughness. He discusses at length controversial subjects and his conclusions coincide for the most part with those of the present investigation.

To discuss fully the contradictory statements with regard to ligament function would necessitate a long paper in itself; hence only a brief review of a few points of disagreement will be considered. The lateral femoral condyle acts as the axis of rotation of the knee (Campbell [5], Valls [45]). The lateral femoral condyle is not the axis of rotation (Fick [18]). Anterior gliding of the tibia on the femur is prevented by the anterior cruciate ligament, and posterior gliding of the tibia on the femur is prevented by the posterior cruciate ligament (Conwell [10], Gallie and LeMesurier [19], Saunders [40], Smith [42], Hey Groves [21], Bristow [4], Jones and Smith [27]). Pringle's discussion [37] of this function is equivocal. Horwitz and Davidson [26] believe the collateral ligaments do more to prevent anteroposterior motion than do the cruciate ligaments. The tibial collateral ligament is relaxed in flexion (Murphy [35], Steindler [43], Bennett [1], Valls [45], McMurray [33]). The tibial collateral ligament, or some portion of it, remains taut in all positions of extension or flexion (Mauck [31], Horwitz [25], Fick [18]). Lateral stability—abduction or adduction of the tibia on the femur—is maintained by the collateral ligaments, the cruciate ligaments, and the menisci (Kreuscher [28], Smith [42]). Abduction of the tibia on the femur tears the tibial collateral ligament, and adduction of the tibia on the femur tears the fibular collateral ligament (Bristow [4], Campbell [7]). Removal of either or both menisci when injured or diseased is the general practice, and a stable knee is obtained (Shands, Hutchinson, and Ziv [41], Chandler [8], Henderson [22], Kreuscher [28], Bristow [4], Bennett [2], etc.).

The cruciate ligaments are the important stabilizers of the knee

(Hey Groves [20], Gallie and LeMesurier [19], Smith [42], Bristow [4]). Cruciate ligaments are vestigial structures (Herzmark [23]). The collateral ligaments are the main stabilizers of the knee joint (Conwell [10], Ryerson [39], Horwitz [25], Bennett [1]). The tibial collateral ligament is the most important ligament of the knee (Milch [34]). Rupture of the anterior cruciate ligament results in no instability (Darrach [16], Saunders [40], Milch [34]). Rupture of the cruciate ligaments gives a permanently disabled knee (Hey Groves [20]). Rupture of the posterior cruciate ligament invariably gives an unstable knee (Gallie and LeMesurier [19]). The anterior cruciate ligament is taut in extension, and the posterior cruciate ligament is taut in flexion (Bennett [1], Jones and Smith [27]). Both cruciate ligaments are taut in extension (Saunders [40]). Some portion of both cruciate ligaments is tense in all positions of extension or flexion (Fick [18]). The anterior and posterior cruciate ligaments are taut in extension and complete flexion, but are relaxed in semiflexion (Smith [42]). According to Steindler [43] and Fick [18], the greatest amount of capsule distention is at 20 to 30 degrees of flexion, while Mayer and Burman [32] lead one to believe this is not true.

If the importance of function of knee-joint ligaments can be based on the clinical necessity of repair, there is considerable controversy. If ruptured collateral ligaments are repaired, ruptured cruciate ligaments seldom need to be repaired (Dickson and Lawrence [17], Cotton and Morrison [11], Bosworth and Bosworth [3], Henderson [22], Mauck [30], Ryerson [39], Darrach [16], Horwitz and Davidson [26], Bennett [1]). Repair of ruptured cruciate ligaments is usually necessary (Cubbins, Conley, Callahan, and Scuderi [15], Cubbins, Callahan, and Scuderi [12, 13, 14], Campbell [6, 7], Strickler [44], Lee [29], Hey Groves [20, 21], Gallie and LeMesurier [19], Mayo Robson [38], Smith [42], Pringle [37]). It is important to repair the collateral and cruciate ligaments if ruptured (Campbell [7], Smith [42], Hey Groves [21]). It would seldom be necessary to repair the collateral ligaments, since repair would be natural, if proper protection were given to the acutely injured knee (Bristow [4]). Many other discrepancies could be given.

METHODS AND MATERIAL OF INVESTIGATION

In the course of a study of approximately 100 knee joints, observations have been made which seem to offer some clarification of the functional rôle of the ligaments of the knee joint, and tend to settle some of the moot points mentioned.

Many of the joints were obtained from thigh amputations, and were studied in the fresh condition, while others were secured from embalmed cadavera.

The joints were dissected in every conceivable manner with special reference to the capsule and ligaments. Tests of function and motion were made in fresh and preserved joints stripped of all parts except the ligaments. Individual ligaments and combinations of ligaments were cut, and the function of the ligaments and motion of these joints were

were split in different planes, and the bone configura- bring into view the ligaments and their activities. The injected, and frozen cross sections were made. The ...ng individual ligaments and combinations of ligaments was ...in fresh intact knee joints. Microscopic studies were made of ...e tibial collateral ligament and medial meniscus.

A duplication of injuries by forced tearing of ligaments or capsule (Pringle [37], Horwitz and Davidson [26], Hönigschmied [24], Pagenstecker [36]), was not attempted because, in the absence of muscular support, force could not be applied in a manner which would duplicate the forces which cause injury in the living subject.

In order to measure more accurately the degree of lateral motion —abduction and adduction of the tibia on the femur—a simple apparatus was devised. A vice was solidly set into a piece of timber. Upright bars with pulleys were made fast to the timber at different levels and positions. The femur was fixed in the vice and a wooden piece fixed to the tibia. By means of a pointer the movements of the tibia could be measured. Lateral and rotary force then could be applied to the tibia under set conditions by suspending weights from the tibia by means of a cord over the upright bars and pulleys. The bars were in different positions to allow the force to be applied on a horizontal plane. For lateral motion a weight of 3.5 kilograms was suspended from the tibia, 10 centimeters distal to the articular surface. By the same method of force application the joint was held in extension—really hyperextension—by a weight of 2.1 kilograms while lateral motion was measured as stated above. For rotation a weight of 2.1 kilograms was suspended 10 centimeters distal to the tibial articular surface on a 7-centimeter lever arm. There was one degree of error in the apparatus. While in extension both lateral and rotary motions could be very accurately measured, but difficulty was encountered in consistently maintaining exactly 90-degree flexion or full flexion. This difficulty probably accounts for inconsistencies in Table I where occasionally, after cutting a ligament, less motion, by a few degrees, was noted. In a stripped joint it is almost impossible to determine accurately the neutral position. Accordingly, the degree of lateral motion is not divided into medial and lateral rotation. [Unfortunately, this is a recent part of the experiment and has been carried out on only twenty-three joints (Table I).]

The figures used in the text are the results of observations on all joints studied, including those measured. There is considerable variation in motion from joint to joint, which makes average figures seem inconsistent when applied to an individual joint.

By a fresh joint is meant one recently amputated and studied without preserving. The joints were kept in the ice box until the study was over, and then were discarded or put in formalin for future reference. To avoid repetition, the statement "fresh intact joint" will mean a fresh joint without anything removed, not even the skin. A "stripped joint"

will indicate a joint with all structures removed down to and including the capsule, but with the ligaments and menisci of the knee joint intact. Lateral motion will mean abduction or adduction of the tibia on the femur, and rotation will mean pronation or supination of the tibia on the femur.

In the fresh joint the ligaments are stronger and more resilient than in the preserved, and, therefore, the motion and function are more nearly normal. Joints preserved in formalin show less lateral and rotary motion than do fresh joints; however, joints obtained from embalmed anatomical cadavera allow more lateral and rotary motion than do the fresh joints.

MOTION OF THE NORMAL KNEE JOINT

In a completely extended knee joint both collateral (Figs. 2*a* and 9*a*) and cruciate (Fig. 12*a*) ligaments are taut, and the anterior aspects of both menisci (Fig. 10*b*) are snugly held between the condyles of the tibia and the femur. The greater the hyperextension, the tighter are these ligaments, and the tighter are held the anterior aspect of the menisci. In the first few degrees of flexion, there is a medial rotation of the tibia on the femur of about 1 to 3 degrees. As flexion continues, the fibular collateral ligament relaxes (Figs. 5*a* and 9*b*) and remains relaxed even in full flexion. The tibial collateral ligament remains taut throughout flexion, but the area of tension is changed from the whole width of the ligament in extension to the anterior portion of its fibers while in complete flexion. The posterior portion of the ligament is then relaxed (Fig. 2). The tibial collateral ligament slides posteriorly on the surface of the tibia with flexion, and its midportion slides from a few millimeters to one centimeter when the joint moves from complete extension to full flexion (Fig. 2). Both cruciate ligaments remain taut throughout flexion and more stress is placed on them in full flexion (Fig. 12). Accordingly, the three ligaments, tibial collateral and both cruciates, remain taut, but not tense, throughout flexion. They are somewhat more taut from about 80 to 100 degrees of flexion. Both menisci slide backward with flexion. Often the medial meniscus moves only a few millimeters backward while the lateral one moves at least one centimeter. In full flexion the posterior aspect of both menisci are snugly pressed between the condyles of the tibia and the femur (Fig. 10*a*).

Since in full extension or hyperextension both collateral and cruciate ligaments are tense, practically no lateral motion or rotation is present (Table I). In flexion with relaxation of the fibular collateral ligament (Fig. 3) there is a variation in rotation of 6 to 24 degrees in fresh intact joints (Table I). The tibia rotates on the femur more in the lateral than in the medial direction. The tibial collateral ligament and both cruciate ligaments remain taut in all positions of flexion but not tense as in complete extension, thus allowing some lateral motion in flexion; the greatest amount of lateral motion is allowed between 30 and

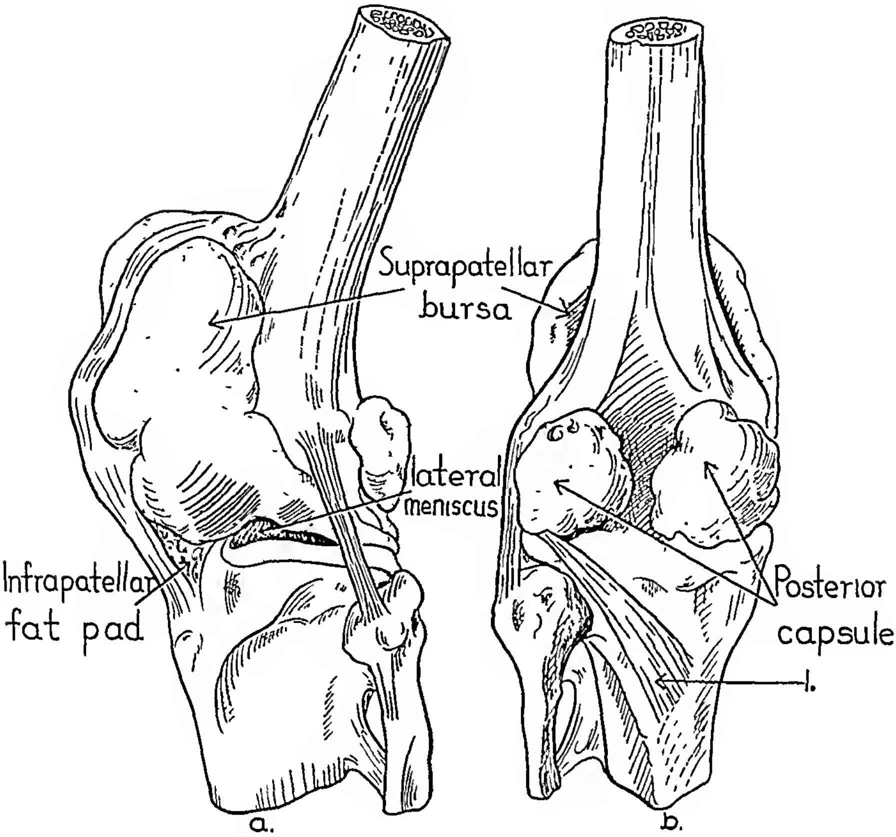

FIG. 1

A mold of a normal distended joint cavity.

A fresh intact joint was injected with dental plaster under slight pressure. The plaster hardened and the joint was stripped of all tissue but ligaments and menisci. The plaster mold represents a normal distended knee-joint cavity and the extent of the synovial membrane. The infrapatellar pad of fat is outside the joint cavity and synovial membrane which stops short at the upper end of the tibia, but extends for a considerable distance over the femur as the suprapatellar bursa. The collateral and cruciate ligaments and the menisci are actually outside the synovial membrane. Posteriorly, the joint capsule and synovial membrane cover the posterior aspect of the femoral condyles individually.

1: Partially removed popliteus muscle and its tendon.

50 degrees of flexion. [At 90 degrees' flexion there is a variation of 4 to 9 degrees of lateral motion in fresh intact joints (Table I).]

The rotation of the femur on the tibia as the joint comes into or leaves complete extension is controlled by the bone architecture of the joint as well as its ligamentous arrangement. The articular surface of the medial femoral condyle is larger than that of the lateral femoral condyle (Fig. 11*a*). In the beginning of flexion the lateral femoral condyle rolls backward considerably farther on the lateral tibial plateau than does the medial femoral condyle on the medial tibial plateau. The greater backward displacement of the lateral meniscus is direct evidence of this. The medial meniscus moves backward very little. The greater backward displacement of the lateral femoral condyle indicates the rotation of the femur; accordingly, the axis of rotation of the knee must be near

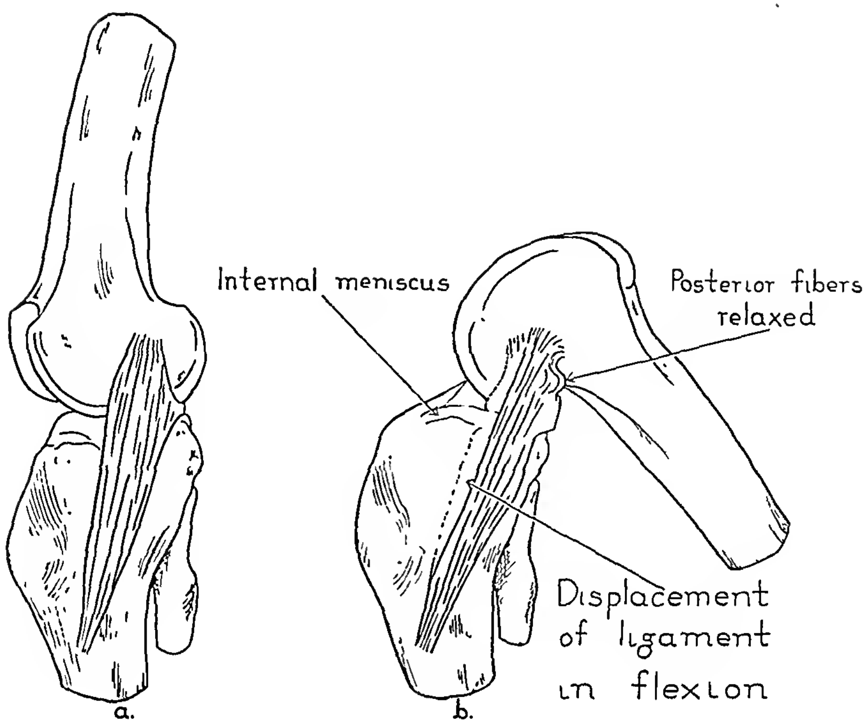

FIG. 2

A stripped joint showing tibial collateral ligament.

a: Tension on the tibial collateral ligament is distributed throughout its width in extension.

b: In flexion the area of tension is shifted to the anterior portion of its fibers while the posterior portion is relaxed. Some portion of the ligament is taut in every position. The sliding of the ligament backward in flexion and forward in extension is indicated.

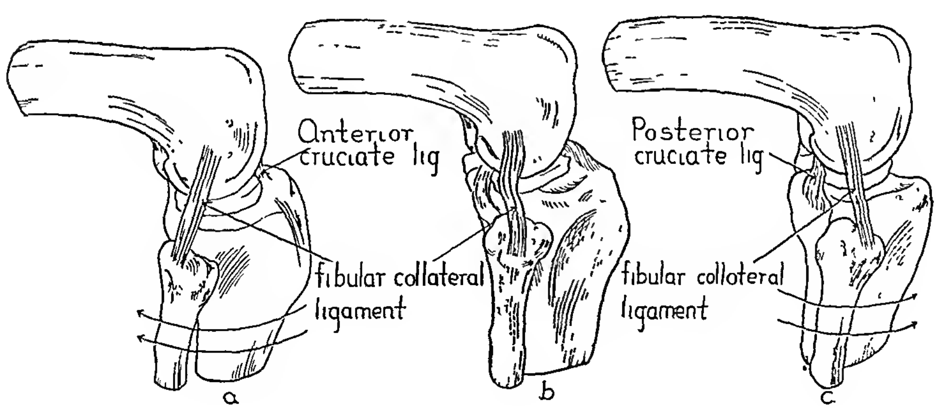

FIG. 3

The lateral aspect of a stripped joint revealing normal medial and lateral rotation. Rotation is normally possible in a flexed knee joint.

a: On lateral rotation of the tibia on the femur the fibular collateral ligament tightens.

b: In the normal position with neither lateral nor medial rotation, the fibular collateral ligament is relaxed.

c: On medial rotation of the tibia on the femur the fibular collateral ligament again tightens. Normal rotation of the tibia on the femur in flexion would not be present if the fibular collateral ligament were not relaxed.

the medial femoral condyle. Greater freedom of motion of the lateral femoral condyle is allowed by the relaxation of the fibular collateral ligament (Fig. 3).

In twenty-five knee joints the tibial collateral ligament was measured from the articular surface of the tibial condyle to the attachment of the ligament to the tibia. The greatest distance was 5.7 centimeters; the shortest, 3.8 centimeters; and the average, 4.6 centimeters. In measuring from the articular surface of the tibial condyle to the distal end of the tibial collateral ligament, the greatest length was 9.5 centimeters; the shortest, 6.4 centimeters; and the average, 7.8 centimeters. The sliding of the tibial collateral ligament forward and backward in extension and flexion (Fig. 2) occurs because the anterior bone attachment of the ligament is distal to the tibial articular surface. The posterior aspect of the ligament is attached to the tibia immediately superior and lateral to the insertion of the semimembranosus muscle. This attachment limits the anterior progress of the ligament in extension, and its relaxation in flexion permits the posterior gliding of the ligament. There is close approximation of this ligament to the medial meniscus, but not a fixed immovable fibrous attachment (Fig. 13). The medial meniscus moves forward in extension and backward in flexion, but not to such a great extent as the tibial collateral ligament. The statements just made are not obvious in preserved specimens, but are readily demonstrated in fresh joints. That the ligament does not have a bone attachment to the tibia throughout its whole distance over the tibia is evident because the inferior medial genicular artery courses between the ligament and the tibia, and often a bursa is interposed between the ligament and the bone.

LATERAL MOTION OF THE KNEE JOINT

In the discussion of lateral motion any abnormal rotation which may be present will be neglected. In a stripped preserved joint there is practically no lateral motion in complete extension. In flexion there are a few degrees of lateral motion which is greatest between 30 and 50 degrees of flexion. With fresh intact joints there is a variation of 2 to 5 degrees of lateral motion in complete extension, and 4 to 9 degrees in 90-degree flexion (Table I). When either (Figs. 4*a* and 4*b*) or both (Fig. 6*a*) collateral ligaments are cut, there is practically no change in the lateral motion if both cruciate ligaments are intact. When both collateral ligaments are intact and either anterior or posterior cruciate ligament is cut, there is no change in lateral motion. If, however, both cruciate ligaments are cut and both collateral ligaments are intact (Fig. 4*c*), there is no abnormal lateral motion in extension, but there is abnormal lateral motion in flexion because then the fibular collateral ligament is normally relaxed (Figs. 5*a* and 5*b*). Abnormal motion present when other combinations of ligaments are cut can be seen by referring to Table I.

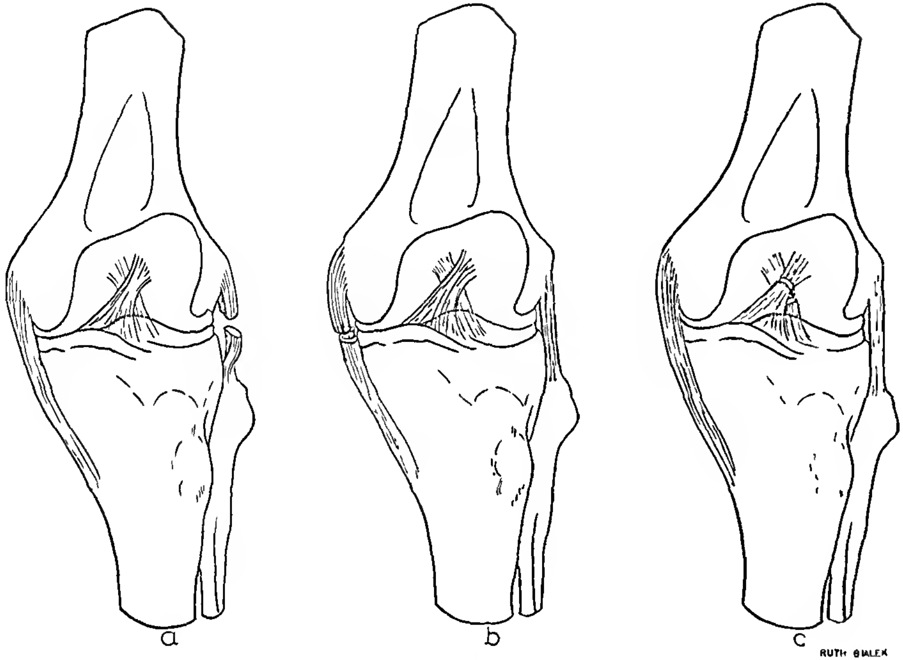

Fig. 4

A stripped joint in extension with various ligaments cut.

a: There is no abnormal lateral motion when only the fibular collateral ligament is cut.

b: There is no abnormal lateral motion when only the tibial collateral ligament is cut.

c: With the joint extended there is no abnormal lateral motion when both cruciate ligaments are cut and both collateral ligaments are intact (See Fig. 5).

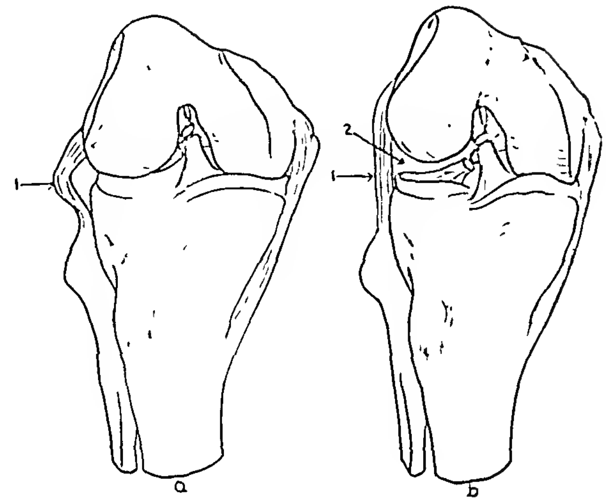

Fig. 5

A stripped joint in flexion with both cruciate ligaments cut and both collateral ligaments and menisci intact.

a: There is relaxation of the fibular collateral ligament (*1*).

b: There is an abnormal amount of lateral motion present (*2*). (Compare with Fig. 4*c* where there is no relaxation of the fibular collateral ligament in extension and no abnormal lateral motion; and with Fig. 12 where tautness of the cruciate ligaments in all positions prevents lateral motion in flexion when the collateral ligaments are cut.)

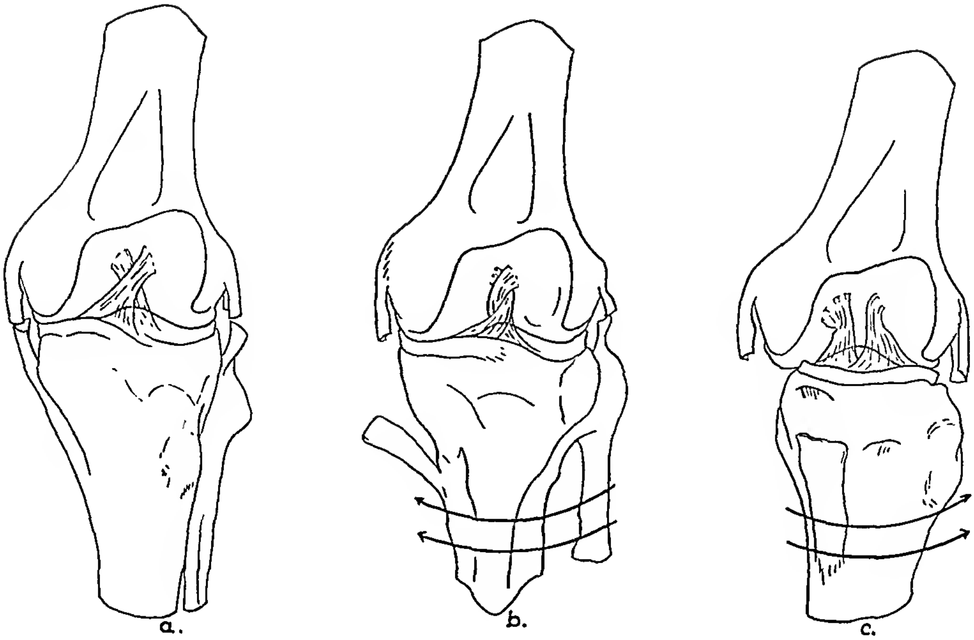

FIG. 6

A stripped joint with both collateral ligaments cut and both cruciate ligaments and menisci intact.

a: There is no abnormal lateral motion of the joint. (This is also true in flexion.)

b: Very little abnormal medial rotation of the tibia on the femur is possible because the cruciate ligaments twist on themselves.

c: Free lateral rotation of the tibia on the femur is possible because the cruciate ligaments untwist in this motion.

In fresh intact joints, when all ligaments are cut, there is a variation of lateral motion of 2 to 11 degrees in extension, 12 to 32 degrees in 90-degree flexion, and 10 to 32 degrees in full flexion (Table I). Reference to Table I will reveal that removal of one or both menisci does not materially change lateral motion. Lateral motion is increased somewhat if rotation is permitted.

Lateral motion of the knee joint in extension is controlled by the capsule, both collateral, and both cruciate ligaments; in flexion it is controlled by the capsule, tibial collateral, and both cruciate ligaments (the fibular collateral is relaxed). (In the living the muscles and tendons about the knee aid in lateral stability.)

ROTARY MOTION OF KNEE JOINT

In the discussion of rotary motion any abnormal lateral motion which may be present will be neglected. In a stripped preserved joint there is practically no rotation in complete extension, but in flexion there is present some rotation (Table I); in the fresh intact joints, the rotation varies from 6 to 24 degrees in the 90-degree position and 4 to 21 degrees in full flexion. Relaxation of the fibular collateral ligament in flexion allows this normal rotation in flexion (Fig. 3). When the tibial collateral ligament is cut, there is no rotary change while in extension, but

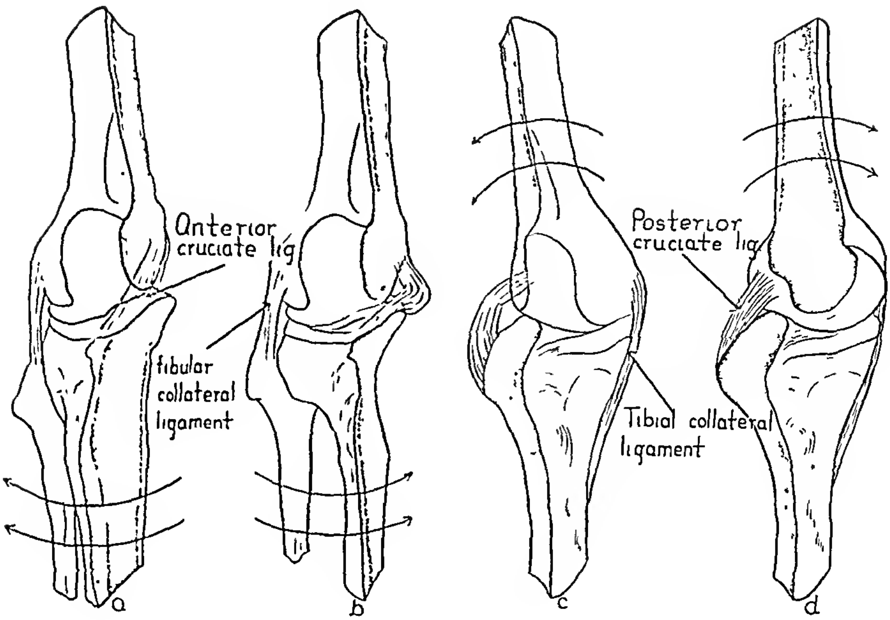

FIG. 7

Two halves of a stripped split joint. In the lateral half of the joint (*a* and *b*), the fibular collateral and anterior cruciate ligaments are intact; in the medial half of joint (*c* and *d*), the tibial collateral and posterior cruciate ligaments are intact.

a: Lateral rotation and anterior gliding of the tibia on the femur are not possible because the pull is in the direction of the attachment of the anterior cruciate ligament.

b: Medial rotation of the tibia on the femur is possible because it relaxes the anterior cruciate ligament, and gliding of the tibia posteriorly on the femur is possible for the same reason.

c: Medial rotation and forward gliding of the tibia on the femur are possible because this motion relaxes the posterior cruciate ligament.

d: Lateral rotation and backward gliding of the tibia on the femur are impossible because the pull is in the direction of the attachment of the posterior cruciate ligament.

in flexion there is about double the normal amount of rotation present (Table I). When the fibular collateral ligament is cut, there is practically no abnormal rotary change in the position of extension or flexion. When the posterior cruciate is cut, there is no rotary change while in extension, but in flexion the amount of rotation is increased (Table I). This is also true for the anterior cruciate ligament. When both cruciate ligaments are cut, there is practically no rotary change in extension, but the rotation while in flexion is three times greater than normal (Table I). When both lateral ligaments are cut, there is present external rotation of about 180 degrees or more in either the extended or flexed position (Fig. 6). It is important to point out, however, that this abnormal rotation is lateral rotation of the tibia on the femur coincidental with the untwisting of the cruciate ligaments (Fig. 6*c*). There is practically no abnormal medial rotation of the tibia on the femur because the cruciate ligaments tend to twist on themselves (Fig. 6*b*); thus the cruciate ligaments alone can control internal rotation of the tibia on the femur.

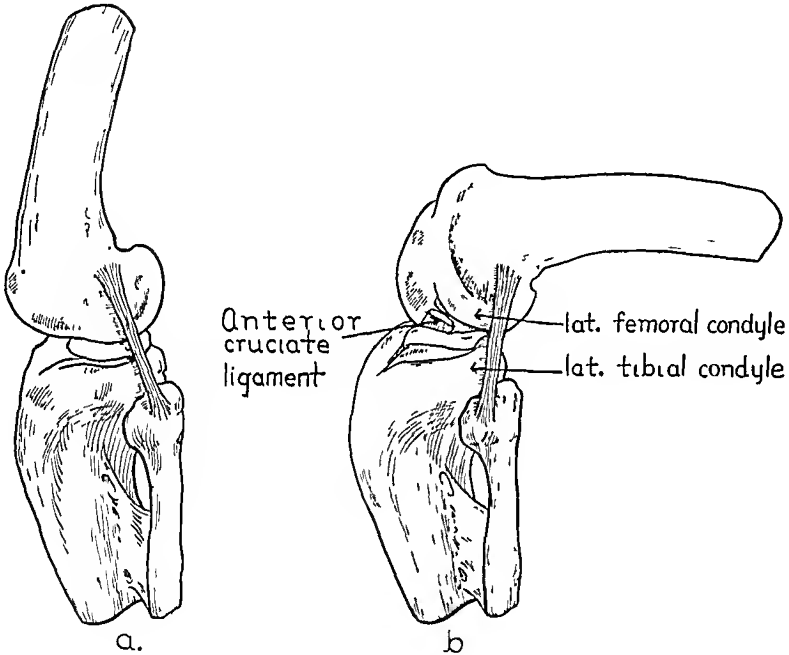

FIG. 8

A stripped joint with anterior cruciate ligament cut.
When the anterior cruciate ligament is cut, the lateral femoral condyle tends to roll off the lateral tibial condyle and the tibia rotates medially. (Relaxed fibular collateral ligament in flexion allows this.) The medial femoral condyle does not tend to roll off the medial tibial condyle.

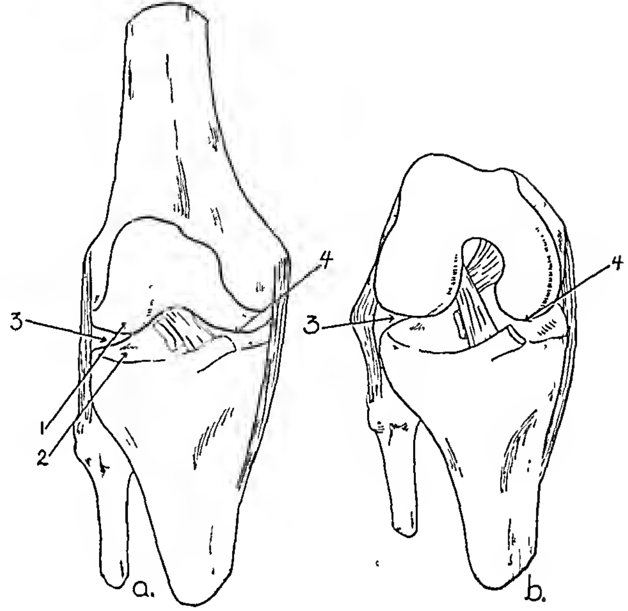

FIG. 9

A stripped joint with both menisci removed; *a:* in extension, and *b:* in flexion.
Note that the medial curved intercondyloid surface of the lateral femoral condyle (*1*) is in contact with the intercondyloid eminence of the lateral tibial condyle (*2*). There is a wide distance separating the articular surfaces of the lateral tibial and the lateral femoral condyles at the periphery (*3*). The medial femoral and tibial condyles have a wider articulating surface (*4*); the medial condyle of the femur is in contact with the intercondyloid eminence of the tibia. The femoral intercondylar space fits snugly over the intercondyloid eminence of the tibial condyles and prevents lateral gliding of the tibia on the femur.

When a stripped joint is split there are two workable halves (Fig. 7). The lateral half has the fibular collateral and anterior cruciate ligaments intact, and the medial half has intact the tibial collateral and posterior cruciate ligaments. When the lateral half is in extension, there is no abnormal lateral rotation because such motion pulls in the direction of the attachment of the anterior cruciate ligament (Fig. 7*a*); however, in flexion there is abnormal lateral rotation because the fibular collateral ligament is relaxed. In the medial half of the joint there is no abnormal lateral rotation of the tibia on the femur in either extension (Fig. 7*d*) or flexion, because the pull is exactly in the direction of the attachment of the posterior cruciate ligament. There is abnormal rotation in the medial direction, however, in both halves, because this motion relaxes the cruciate ligaments (Fig. 7*b* and 7*c*). This reveals that the cruciate ligaments, working in association with the collateral ligaments, help control lateral rotation of the tibia on the femur. Reference to Table I will reveal rotary changes that occur when other combinations of ligaments are cut. Removal of one or both menisci does not materially change the rotary stability of the joint (Table I).

In the fresh intact joints, when all ligaments are cut, there is a variation of rotary motion of 4 to 25 degrees in extension, 22 to 42 degrees in 90-degree flexion, and 10 to 33 degrees in full flexion (Table I).

Rotary stability of the knee joint in extension is controlled by the capsule, both collateral, and both cruciate ligaments; in flexion, by the capsule, tibial collateral, and both cruciate ligaments (the fibular collateral ligament is relaxed).

BACKWARD AND FORWARD GLIDING OF THE TIBIA ON THE FEMUR

In the study of forward and backward gliding of the tibia on the femur other abnormal motions will be omitted. There is no demonstrable forward or backward motion when the preserved or fresh stripped joint is intact. In the stripped preserved joint, when the posterior cruciate ligament is cut, there is only a millimeter or two of backward gliding of the tibia on the femur in extension, but this is increased in flexion. Extension and flexion of the joint are practically normal. When the anterior cruciate ligament is cut, there is only a millimeter or two of forward gliding of the tibia in extension, but in flexion this is increased about three times. In such a joint extension is normal, but in full flexion the lateral femoral condyle tends to roll completely off the lateral tibial condyle (Fig. 8). (One cadaver specimen revealed an old rupture of the anterior cruciate ligament, and this joint showed the same findings.) The lateral femoral condyle is allowed to roll off the lateral tibial condyle because the fibular collateral ligament is relaxed in flexion (Fig. 5*a*). Of course, this would not occur if the capsule were intact. In extension when both cruciate ligaments are cut and both collateral ligaments are intact, the gliding forward and backward of the tibia on the femur is about

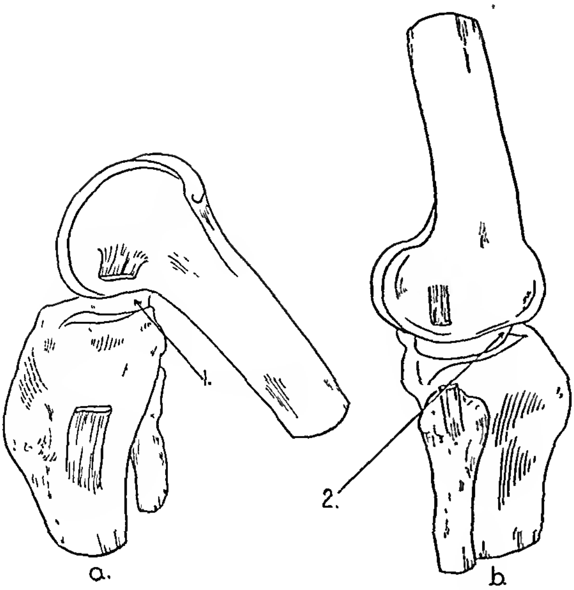

FIG. 10

A stripped joint showing the relationship of the menisci to the condyles in full flexion (*a*) and complete extension (*b*). The collateral ligaments in the drawings were removed for clarity but were intact in the joint tested.

a: In hyperflexion the posterior aspect of the medial meniscus acts as a cushion between the femur and the tibial condyle (*1*). (A drawing of the lateral meniscus would reveal the same condition.)

b: In hyperextension the anterior aspect of the lateral meniscus is snugly held by the lateral condylar notch and the tibial condyle, thus acting as a cushion (*2*). (A drawing of the medial meniscus would reveal somewhat the same condition.)

5 to 6 millimeters. This small amount of motion is due to the definite tightening of the collateral ligaments in complete extension. In flexion the forward and backward gliding amounts to about 10 to 12 millimeters, and the lateral femoral condyle again tends to roll off the lateral tibial condyle. Greater forward and backward gliding is not present in the preserved joint, because the tibial collateral ligament is more intimately attached to the tibia and medial meniscus by the hardening of the intervening areolar tissue by the fixing solution; thus the tibial collateral ligament does not slide on the tibia as it does in the fresh joint. Accordingly, the tibial collateral ligament prevents excessive forward and backward gliding of the medial side of the tibia on the femur in preserved joints, but not in fresh joints. In the stripped fresh joint with both cruciate ligaments cut and both collateral ligaments intact, the amount of forward and backward gliding in extension depends considerably on the force of hyperextension, but in flexion there is about 1.5 to 2.0 centimeters. The attachment of the posterior aspect of the tibial collateral ligament to the posterior surface of the tibia limits the forward and backward gliding of the medial tibial condyle on the femur when the joint is in extension. However, in flexion the posterior portion of the tibial collateral ligament is relaxed and therefore exerts no control over this motion. (If rotation is permitted, the anterior and posterior gliding appears greater.) In the intact fresh joint with both cruciate ligaments cut, it is difficult to measure accurately the amount of forward and backward motion, but it corresponds quite well with the findings stated. However, the rolling of the lateral femoral condyle off the lateral tibial condyle, when the anterior cruciate ligament or both cruciate ligaments are cut, is not noticeable, as this is prevented by the capsule and soft structures. When all ligaments are cut, there is a variable amount of forward and backward motion, usually about 2.5 centimeters in flexion.

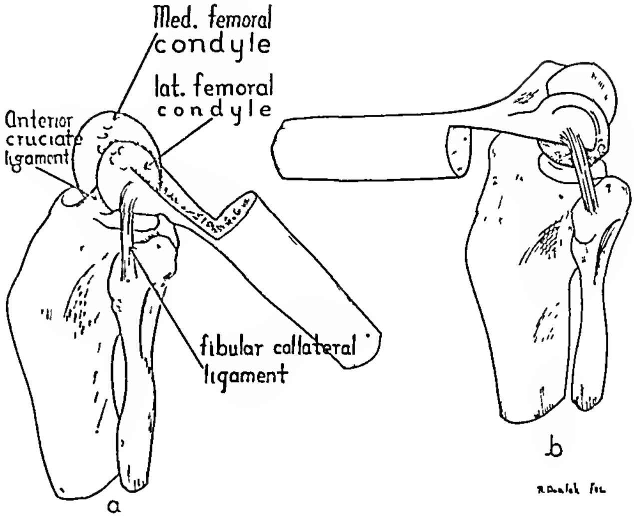

FIG. 11

A stripped joint with all ligaments and menisci intact but with the patellar surface of the femoral condyles removed.

a: The joint is in normal full flexion.

b: The joint will move into slightly more than 90-degree hyperextension. Note the femoral condyles are elliptical in outline and the medial femoral condyle is almost twice as large as the lateral femoral condyle. Ligament control and tension are unchanged.

The anterior cruciate ligament prevents forward gliding of the tibia on the femur because such force is directed in the line of the attachment of the anterior cruciate ligament (Fig. 7*a*). The posterior cruciate ligament prevents backward gliding of the tibia on the femur because such force is directed in the line of attachment of the posterior cruciate ligament (Fig. 7*d*).

Since the anterior and posterior cruciate ligaments are taut in all positions of extension and flexion (Fig. 12), they are very important in maintaining the exact normal anatomical relationship between the tibial and femoral condyles.

Reference to Table I will indicate that the tibial collateral and anterior cruciate ligaments probably add greater stability to the knee joint than do the fibular collateral and the posterior cruciate ligaments.

LATERAL GLIDING OF THE TIBIA ON THE FEMUR

The possibility of lateral gliding of the tibia on the femur can be dismissed with a few words about the bone architecture of the condyles. The intercondyloid eminence of either tibial condyle so fits in the curved articular surface of the intercondyloid fossa of the femur that definite bone contact prevents any lateral gliding in either direction (Fig. 9). Of course, with ligaments cut allowing excessive lateral motion, this bone structure is obviated.

HYPEREXTENSION AND HYPERFLEXION

In the stripped joint both collateral (Figs. 2*a* and 9*a*) and cruciate ligaments (Fig. 12*a*) are taut in complete extension, and the anterior aspects of the menisci (Fig. 10*b*) are held snugly in the notches of the medial and lateral femoral condyles. As hyperextension is attempted, all four ligaments become very tense; and the anterior aspect of both menisci becomes definitely compressed between the femoral and tibial condyles. The architecture of the femoral condyles, and to a lesser degree the attachment of the ligaments, brings this about. The portions

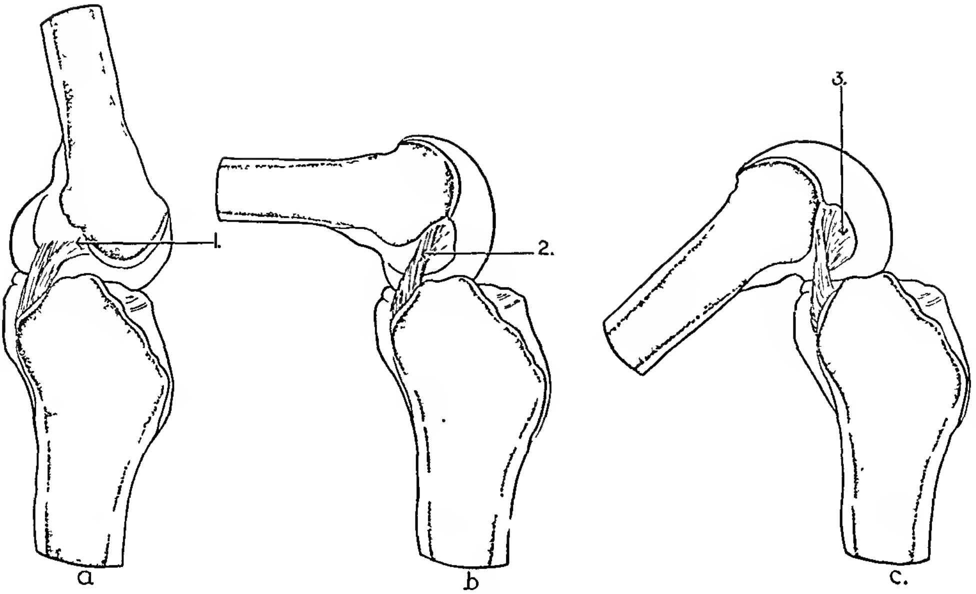

FIG. 12

The split surface of the medial half of a split, stripped joint. The tibial collateral and posterior cruciate ligaments are intact. The manner of attachment and the rolling of the posterior cruciate ligament keep some portion of it taut in all positions of extension and flexion.

a: The posterior cruciate ligament prevents hyperextension, with the greatest stress on the fibers of the posterior position. The attachment (*1*) of this ligament to the femur is horizontal to the joint in extension.

b: Partial flexion shows smoothly changing tension from the posterior to the anterior fibers as the ligament rolls upon itself (*2*).

c: The posterior cruciate ligament prevents hyperflexion, with greatest stress on the anterior fibers. Its attachment to the femur is vertical to the joint in full flexion (*3*).

(A similar view of the lateral half of a split joint would show essentially the same features for the anterior cruciate ligament.)

of the femoral condyles that are in relation to the tibial condyles have definitely a smaller curve than the portions that are in relation to the patella. This abrupt change in the curve of the condyles wedges the tibial portion of the femoral condyles away from the tibial condyles, thus attempting to lengthen the distance between the attachments of the ligaments. The medial and lateral femoral condylar grooves, being most prominent on the lateral condyle, aid in holding the menisci from gliding farther forward (Fig. 10*b*).

When the femoral condyles are cut away and the ligaments left intact (Fig. 11), the joint will go into more than 90 degrees' hyper-extension. The femoral condyles cut in such a manner are elliptical in contour.

As the joint is flexed, the fibular collateral ligament relaxes and remains so even in complete flexion. The tibial collateral ligament shifts its tension from the whole width of the ligament to the anterior fibers, but some portion remains taut in all degrees of flexion (Fig. 2).

It can be shown on either half of the split stripped joint that both the anterior and posterior cruciate ligaments remain taut throughout all degrees of flexion and become definitely tense when hyperextension is attempted (Fig. 12*c*).

When an x-ray of a living knee joint in full forced flexion is compared with a stripped joint in full flexion, the stripped joint has about 10 to 15 degrees more flexion. In the stripped joint full flexion finally is limited by the bone portion of the femur above the condyles coming in apposition with the tibial condyles and being cushioned by the posterior aspects of the menisci (Fig. 10*a*). In the intact joint as well as in the living joint the femoral attachment of the posterior aspect of the capsule and the femoral attachment of both heads of the gastrocnemius muscle act with the menisci as a cushion, limiting hyperflexion.

Approximately twelve attempts were made to dissect a joint down to the capsule, leaving the capsule intact. This could not be accomplished on the anterior and anterolateral aspect of the joint, but could be easily accomplished on the posterior aspect. Anteriorly, the capsule could always and easily be demonstrated from the periphery of the tibial articular surface to the menisci, but above the menisci it blended with tendons and deep fascia of the extremity in such a way that it was always lost. The patellar tendon, patella, and quadriceps tendon replace the capsular structure in their respective regions.

In hyperextension the posterior aspect of the capsule and the oblique popliteal ligament are tense. In hyperflexion the capsule apparently takes no part in checking the motion.

Hyperextension is checked by both collateral ligaments, both cruciate ligaments, the posterior aspect of the articular capsule, the oblique popliteal ligament, the anterior aspect of the menisci, and especially the architecture of the condyles of the femur.

Hyperflexion is checked by both cruciate ligaments, the posterior aspect of the menisci, the femoral attachment of the posterior aspect of the capsule, the femoral attachment of the gastrocnemius muscle, and the bone architecture of the femur. The cruciate ligaments are most important. (In the living, muscle action will have much to do with checking both hyperextension and hyperflexion.)

THE MENISCI

The motion of the menisci has been discussed. Their cushioning effect in hyperextension and full flexion was noted. The lateral meniscus is smaller in diameter, thicker about the periphery, and usually wider than the medial. In addition to its strong bone attachment, it is attached to the anterior cruciate ligament in front and the posterior cruciate ligament behind by strong fibrous tissue. (When present, the ligament of Wrisberg attaches the lateral meniscus to the femur.) It is separated from the fibular collateral ligament by the popliteus tendon. The medial meniscus is much larger in diameter, thinner about the periphery, usually narrower, and has no fibrous attachment to either cruciate ligament. It is closely related to the tibial collateral ligament, but only by areolar tissue. There is no strong fibrous attachment between the tibial collateral ligament and the medial meniscus (Figs. 13 and 14), and often a bursa is interposed.

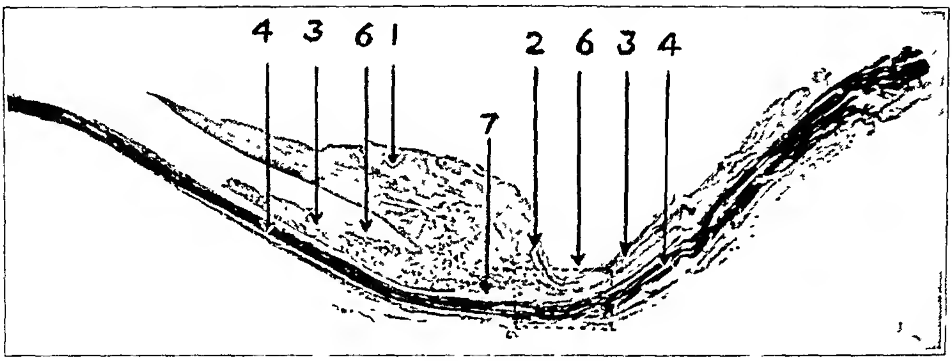

FIG. 13

Photomicrograph of the medial meniscus and tibial collateral ligament. In gross dissection of fresh knee joints the tibial collateral ligament can be stripped from the medial meniscus with the handle of the scalpel. A block of tissue was taken from each of six fresh joints, removing a portion of the tibial collateral ligament with a corresponding portion of the medial meniscus. Sections were made parallel with the fibers of the tibial collateral ligament approximately through its center.

1 shows the medial meniscus; *2*, the junction of the capsule of knee joint and the meniscus revealing fibrous tissue attachment; *3*, true capsule of knee joint; *4*, tibial collateral ligament; *6*, synovial membrane; and *7*, bursa. The area enclosed by dotted lines is shown in higher magnification in Fig. 14.

The fibrous tissue of the true capsule of the knee joint blends intimately with the menisci about the periphery (Fig. 13). The lateral meniscus, however, is separated from the capsule where the popliteus tendon enters the joint. The circle enclosed by the medial meniscus is several times larger than the circle enclosed by the lateral meniscus. A study of the circles enclosed by the two menisci reveals that the articular surface of

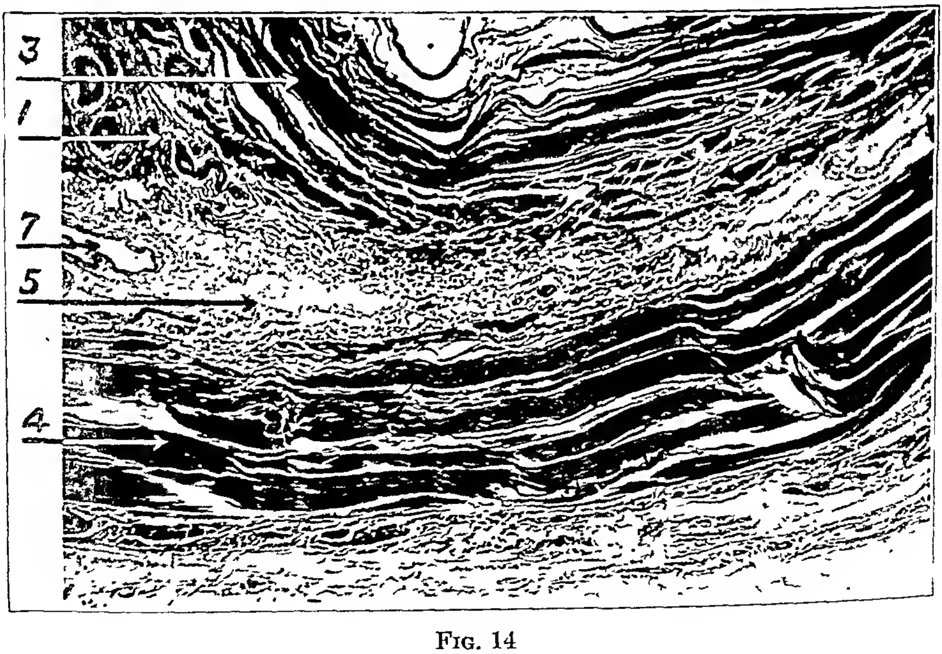

FIG. 14

Photomicrograph of section taken from Fig. 13. *1* indicates the medial meniscus; *3*, the true capsule of knee; *4*, the tibial collateral ligament; *5*, areolar tissue between the medial meniscus and the tibial collateral ligament; and *7*, the bursa with its lining membrane.

the medial femoral condyle is in apposition with the tibial condyle over a rather broad area adjacent to the medial intercondyloid eminence (Fig. 9), while the lateral femoral condyle is in apposition with the tibial condyle over a very small area adjacent to the lateral intercondyloid eminence; thus leaving a large area about the periphery of the lateral tibial and femoral condyles rather wide apart (Fig. 9). This, of course, is evident because the lateral meniscus about the periphery is thicker than the medial.

This observation suggested a review of 100 diagnostic roentgenograms of the knee joint. These were picked at random, except for the rejection of those with destructive lesions or joint fractures. Only those in or near extension were measured, and in all the smallest space interval was used. Where there was overlapping of bone and no space, the overlap was measured and recorded as a minus quantity. The anteroposterior view was used. The average joint space on the medial side was 0.53 millimeters and on the lateral side, 3.48 millimeters; the average difference in the joint spaces was 2.95 millimeters. The greatest joint space on the medial side was 6.8 millimeters, and on the lateral side 9.2 millimeters. The greatest difference between the medial and lateral spaces was 7.2 millimeters; the smallest difference was 0.4 millimeters. On the face of this evidence it seemed that there should be abnormal lateral motion present when the lateral meniscus was removed, but on both preserved and fresh joints this was not borne out (Table I).

The menisci cushion hyperextension and hyperflexion. (The menisci do not cushion a blow from above or below because condylar articular contact between the tibia and the femur is always present.) The menisci fill an otherwise dead space between the periphery of the condyles of the tibia and the femur, and keep capsule and synovia from becoming pinched between the femoral and tibial condyles. (One complete discoid cartilage was found in this series of joints.)

The ligament of Wrisberg, when present, tends to control the lateral meniscus, pulling it backward in flexion and preventing it from sliding too far forward in hyperextension.

The alar folds, ligament mucosa, and transverse ligament seem to defy assignment to a concrete function. When present the transverse ligament is taut in hyperextension, tending to prevent excessive separation of the anterior aspect of the menisci.

DISCUSSION

The following statements are generally accepted without controversy: Both collateral ligaments are taut in complete extension. The cruciate ligaments by twisting on themselves prevent abnormal medial rotation of the tibia on the femur. In the beginning of flexion the femoral condyles roll on the tibial condyles (certainly the lateral femoral condyle rolls on the lateral tibial condyle, but whether the medial femoral condyle rolls at all is under investigation), and, after a certain degree of

flexion, the femoral condyles glide at one point on the tibial condyles. There is a small amount of lateral motion present in the normal knee joint. A certain amount of rotation is normally present in the flexed

TABLE I

CONTROL BY THE LIGAMENTS OF LATERAL AND ROTARY MOTION IN FRESH INTACT AND PRESERVED KNEE JOINTS *

Ligaments Cut	Joint No.	Fresh Intact Joints						Joint No.	Stripped Preserved Jo				
		Degree of Lateral Motion			Degree of Rotation				Degree of Lateral Motion			Degre Rotat	
		Hyper-extension	90-Degree Flexion	Full Flexion	Hyper-extension	90-Degree Flexion	Full Flexion		Hyper-extension	90-Degree Flexion	Full Flexion	Hyper-extension	90-Degree Flexion
one	1	2	4	3	2	6	6						
ibial Collateral	1	2	5	5	2	12	12	9	2	6	5	2	29
oth Collaterals	1	5	5	5	2	20	15	10	1	2	1	180?	180
oth Collaterals and Anterior Cruciate	1	10	10	10	20	25	20						
l Ligaments	1	10	18	13	25	35	20						
one	2	2	5	3	5	7	9						
bular Collateral	2	3	6	4	5	9	9	11	3	1	1	4	10
bular Collateral and Anterior Cruciate	2	7	11	8	11	15	11	12	13	13	9	12	50
oth Collaterals and Anterior Cruciate	2	11	17	9	13	23	9						
ll Ligaments	2	11	18	10	13	25	10						
one	3	5	6	8	2	16	18						
osterior Cruciate	3	4	9	9	6	14	12	13	2	6	9	2	25
oth Cruciate Ligaments	3	4	9	8	7	17	14	14	2	10	15	2	44
oth Cruciates and Fibular Collateral	3	4	9	7	6	18	18						
ll Ligaments	3	5	21	14	6	22	14						
one	4	5	9	5	10	18	7						
nterior Cruciate	4	6	9	8	10	17	9	15	4	5	11	3	13
nterior Cruciate and Tibial Collateral	4	7	15	9	10	27	7	16	Defies Measuring				
oth Cruciates and Tibial Collateral	4	6	31	19	10	31	10						
ll Ligaments	4	6	32	27	10	33	19						
one	5	2	5	3	2	15	11	17	1	3	2	1	15
one—Lateral Meniscus Removed	5	3	6	6	2	18	15	18	1	6	4	1	10
one—Both Menisci Removed	5	3	5	6	4	20	19	19	2	6	6	2	19
oth Menisci and Tibial Collateral	5	3	10	7	6	24	19						
oth Menisci and Both Collaterals	5	3	13	10	7	30	26						
lenisci, Both Collaterals, and Anterior Cruciate	5	7	16	9	13	29	24						
lenisci, Both Collaterals and Cruciates	5	6	17	14	12	27	24						
one	6	2	8	7	4	24	21						
one—Medial Meniscus Removed	6	2	9	8	4	21	21	20	1	1	1	1	4
ledial Meniscus, Posterior Cruciate, and Tibial Collateral	6	9	28	27	6	48	34	21	14	55	57	30	107
ledial Meniscus, Posterior Cruciate, and Both Collaterals	6	11	32	32	10	49	36						
lone	7	2	4	3	2	10	4						
ibial Collateral	7	2	7	4	2	10	5						
oth Collaterals	7	2	6	3	2	10	5						
oth Collaterals and Anterior Cruciate	7	2	9	5	4	12	6						
ll Ligaments	7	2	12	12	4	25	15						
None	8	2	4	6	5	11	15						
Fibular Collateral and Posterior Cruciate	8	4	10	13	6	24	19	22	4	16	19	24	39
All Ligaments	8	6	29	25	11	42	33						
None—Medial Meniscus Displaced								23	2	6	5	1	13

* Ligaments were cut through a small incision in the joint and incision sutured in the intact fresh join

position. There is lateral rotation of the femur on the tibia in the first few degrees of flexion. The posterior aspect of the capsule and the oblique popliteal ligament aid in preventing hyperextension. The fibular collateral ligament is relaxed in flexion.

All agree that muscular, tendinous, and fascial structures about the knee make up one of its important stabilizers and add great strength to the joint.

It is generally accepted that the tibial collateral ligament is intimately attached to the medial meniscus by fibrous tissue (Campbell [5], Henderson [22], Saunders [10], Horwitz [25], Smith [12], Valls [45], etc.). From the study of the present series of joints, it seems evident that there is no strong fibrous tissue connecting these two structures. To verify this, further investigation is being carried on.

Motion of the menisci gives good evidence that the medial femoral condyle acts more nearly as the axis of rotation of the knee joint. The backward or forward motion of the menisci is controlled by the movement of the femoral condyles. In moving from extension to flexion the lateral meniscus moves backward a considerable distance which indicates the rolling backward of the lateral femoral condyle and corresponds to the lateral rotation of the femur. The medial meniscus moves backward only very slightly.

It is evident from its attachments and position that the anterior cruciate ligament prevents forward gliding of the tibia on the femur, and the same can be said about backward gliding being prevented by the posterior cruciate ligament. However, in hyperextension both collateral ligaments are tight and, therefore, by forcing the tibia and femur tightly together will reduce such motion to a minimum. In determining the effect of the tibial collateral ligament on this function, its attachment must be carefully considered. If it were firmly attached to the whole adjacent portion of the tibia, it would prevent forward and backward motion of the tibia on the medial side, but it is not so attached. Its posterior attachment, however, does limit posterior gliding on the medial side while in complete extension, though its posterior portion is relaxed in flexion. The fibular collateral ligament cannot possibly exert any effect in flexion because it is relaxed. Clinically, anterior and posterior motion can always be demonstrated under the relaxation of anaesthesia if either the anterior or posterior cruciate ligament is ruptured (Pringle [37], Milch [34], Cubbins, Callahan, and Scuderi [12]).

That some portion of the tibial collateral ligament is taut in all phases of extension and flexion is evident from the fact that abnormal rotation of the joint is prominent when this ligament is cut.

It is evident from Table I and the work already discussed that both collateral ligaments, both cruciate ligaments, and the capsule are important in maintaining the lateral stability of the joint. Clinically, collateral ligament injuries have associated cruciate ligament injuries and there may or may not be menisci injuries (Cubbins, Callahan, and Scuderi [13], Camp-

bell [6], Conwell [10], Bosworth and Bosworth [3], Valls [45], Conwell and Alldredge [9]). Considering the small part the menisci play in lateral stability, one has only to consider the well-established fact that a normally functioning knee usually results when one or both menisci are removed at operation. This is borne out by Table I.

The most relaxed position of the joint capsule is from 15 to 30 degrees of flexion because all the joints assumed this position when distended by the injection of plaster. In order to have the joint in the extended position, it had to be held so until the plaster hardened.

In discussing the advisability of repairing the anterior cruciate ligament only or the tibial collateral ligament only when both are ruptured, it is probably safe to state that both should be repaired. In the knee joint there is a very close interrelationship among the functions of the collateral and cruciate ligaments, and the capsule. It is hardly possible to give one or more separate and definite functions to any one ligament. When the capsule is incised and sutured, it is intentionally or unintentionally tightened. If either the tibial collateral ligament or the anterior cruciate ligament is repaired, when both are ruptured, then there is restored to normal all but one of the five important stabilizing structures of the knee joint (disregarding muscular support). Therefore, the repair of either the tibial collateral or the anterior cruciate ligament gives a satisfactorily functioning knee joint. The close interrelationship of the ligaments is the important factor in restoring stability, and not the greater importance of one ligament over the other.

CONCLUSIONS

The integrity of the knee joint depends upon the muscles and tendons about the knee, the articular capsule, the intrinsic ligaments of the joint, and the bone architecture of the tibia and femur.

Lateral motion of the knee joint in extension is controlled by the capsule, collateral ligaments, and cruciate ligaments; in flexion, by the same structures minus the fibular collateral ligament.

Rotary motion of the knee joint in extension is controlled by capsule, collateral ligaments, and cruciate ligaments; in flexion, by the same structures minus the fibular collateral ligament.

Forward gliding of the tibia on the femur is controlled by the anterior cruciate ligament.

Backward gliding of the tibia on the femur is controlled by the posterior cruciate ligament.

Lateral gliding of the tibia on the femur is controlled by the tibial intercondyloid eminence and the femoral condyles with the aid of *all* the ligaments.

Hyperextension is controlled by both collateral ligaments, both cruciate ligaments, both menisci, the posterior aspect of the articular capsule, the oblique popliteal ligament, and the architecture of the femoral condyles.

Hyperflexion is controlled by both cruciate ligaments, both menisci, the femoral attachment of the posterior aspect of the capsule, the femoral

attachment of both heads of the gastrocnemius muscle, and the bone structure of the condyles of the femur and the tibia.

The menisci cushion hyperextension and hyperflexion.

The tibial collateral ligament is closely related to the medial meniscus, but there is no strong fibrous-tissue attachment between them.

The tibial collateral ligament glides forward and backward in extension and flexion.

The drawings from which were made Figures 1 to 12 are the work of Ruth Bialek.

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THE CONSERVATIVE COMPENSATION-DEROTATION TREATMENT OF SCOLIOSIS *

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The law that adequate treatment of deformity implies complete restoration of form as well as of function cannot be applied to the case of structural scoliosis without qualification.

In the first place, one cannot speak of restoration of form in the strict anatomical sense except in a few cases. In the second place, if recovery of function means complete automatic muscle-controlled stability and mobility, it is a requirement which can be met fully only in rare instances. Consequently, according to the standard of treatment in other deformities, the treatment of scoliosis is a compromise.

We believe that this compromise is acceptable for three reasons.

1. The important factor in the deformity is not the curve itself, but rather the loss of posture which it involves—the lack of alignment between the head, shoulders, and pelvis—so even if it is not possible to restore the anatomical form of the column, it is possible in a majority of cases, to approach a normal posture. We call this the realignment of the spine by compensation.

2. When this passive realignment is once obtained, the musculature can in a great many cases, be adequately developed to maintain actively the posture so regained, even though the mobility of the spine has been greatly reduced by the scoliosis.

3. In the absence of adequate musculature, the entire mobility of the spine can be sacrificed by fusion, and the posture thus maintained passively.

In any event, restoration of alignment or posture is a necessary prerequisite. The question then is, whether the two prerequisites of successful conservative treatment—the degree of compensation necessary to restore posture or general trunk alignment, and the degree of muscle function required to maintain it actively—are available.

It is practically impossible to answer this question at the outset except in the negative sense. For instance, we may be certain that in a severe high thoracic or thoracocervical scoliosis satisfactory realignment cannot be obtained, or that, in a case of paralytic scoliosis, adequate muscle development is out of the question. In the great majority of cases, however, realignment and maintenance of posture represent two

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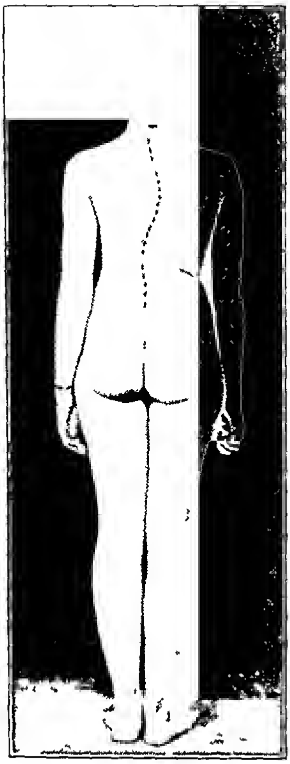

FIG. 1-A

FIG. 1-B

Photograph (Fig. 1-A) and roentgenogram (Fig. 1-B) show habitual scoliosis with a spontaneous compensation of a thoracic curve of 55 degrees by a lumbar curve of 57 degrees. Compensation is holding after four years.

individual variables which only long study and observation of the specific case can evaluate.

TYPES OF CASES

In practice we meet five types of cases as follows:

1. Those which realign or compensate themselves spontaneously and, with adequate muscle power at their disposal, maintain such correction during the period of rapid growth and after adolescence (Figs. 1-A and 1-B). This is a small group of 30 per cent.

2. Those in which adequate compensation can be accomplished by conservative means, without destroying the stability of the spine, and in which, also, adequate muscle tone to maintain such correction can be developed by conservative treatment. Here belong the majority of slight and moderate habitual and rachitic cases (Figs. 2-A, 2-B, 3-A, and 3-B).

3. Those in which adequate compensation can be maintained, and where adequate muscle power can be developed, but where, because of marked adaptive or congenital osseous changes, and in spite of good musculature, compensation is likely to break down again. The more severe habitual cases, still progressing, and the congenital cases, especially those with an oblique fifth lumbar vertebra, belong to this group. The spines of these patients probably should be fused.

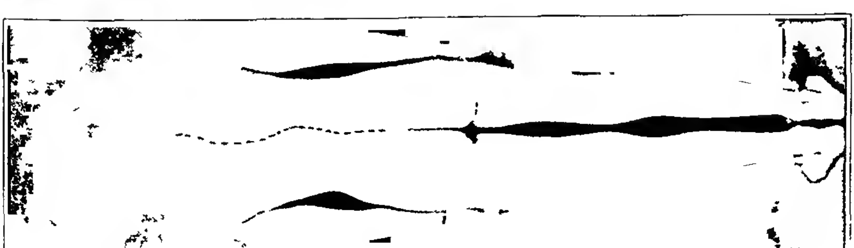

FIG. 2-A

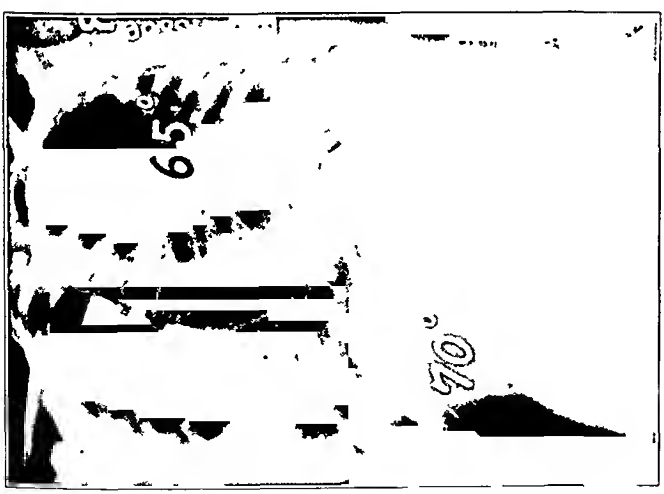

FIG. 2-B

Photograph (Fig. 2-A) and roentgenogram (Fig. 2-B) show habitual scoliosis. Compensation of a thoracic curve of 65 degrees by a lumbar curve of 70 degrees was obtained by conservative treatment. Compensation is holding after four years.

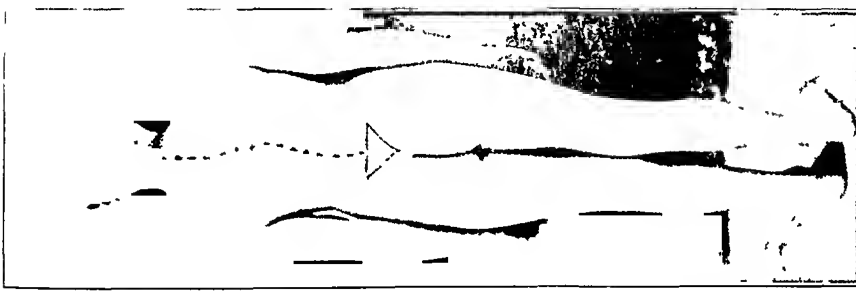

FIG. 3-A

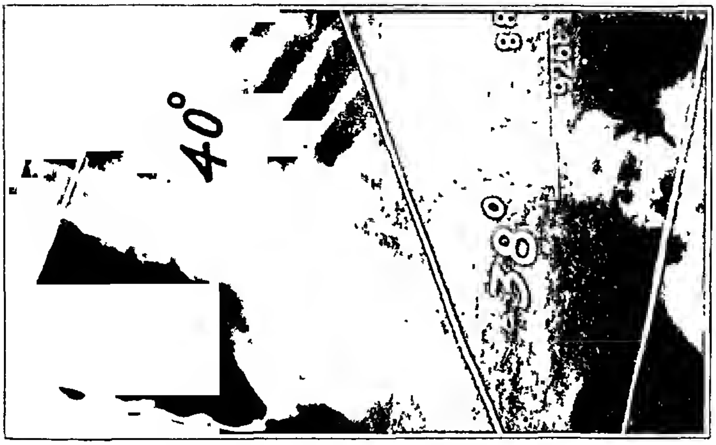

FIG. 3-B

Photograph (Fig. 3-A) and roentgenogram (Fig. 3-B) show rachitic scoliosis. Compensation of a thoracic curve of 40 degrees by a lumbar curve of 38 degrees was obtained by conservative treatment. Compensation is holding after three years.

4. Those in which alignment is possible, but no adequate muscle tone can be obtained. This includes most paralytic cases. The spines in these cases also should probably be fused.

5. Those which cannot be adequately realigned because of severe

Fig. 4

Roentgenogram showing congenital scoliosis Observation time two years.

Fig. 5

Roentgenogram showing habitual scoliosis. Observation time four years.

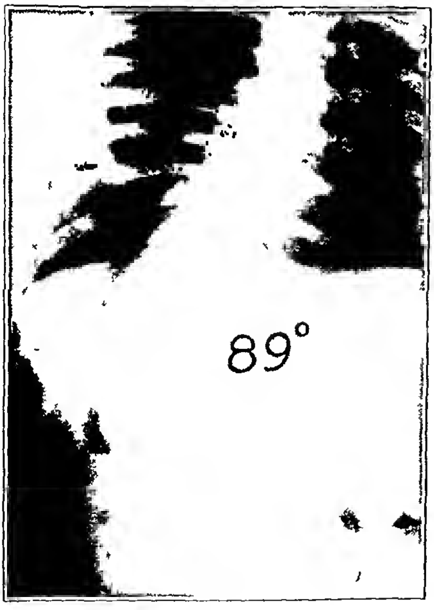

Fig. 6

Roentgenogram showing paralytic scoliosis. Observation time five years.

Fig. 7

Roentgenogram showing rachitic scoliosis. Observation time six years.

Figs. 4–7 illustrate scolioses which were not compensable.

structural deformity. These include the most severe congenital cases (Fig. 4); the severe and inveterate habitual type (Fig. 5); the most severe paralytic type (Fig. 6); and those with a severe cervicothoracic rachitic curve. If the condition is still progressing, the spine should be fused; if it

Fig. 8

Roentgenogram showing a thoracic curve compensated by a lumbar curve

Fig 9

Roentgenogram showing a high thoracic curve compensated by a cervicothoracic curve

Fig. 10

Roentgenogram showing a thoracolumbar curve compensated by a lumbosacral curve

Fig. 11

Roentgenogram showing a long thoracic curve compensated by a cervicothoracic and a lumbar curve.

is already set, it should be left alone or treated by support. In neither instance is the treatment satisfactory.

ALIGNMENT BY COMPENSATION-DEROTATION

Adequate Alignment

In an adequate alignment by compensation-derotation a perpendicular line, drawn from the middle of the bimastoid line and passing through the mid-point of the shoulder line, should strike the gluteal cleft. The compensation, by the development of one or more countercurves of the opposite order, abolishes obliquity of the shoulder line, elevation of the shoulder, and protrusion of the pelvis on the concave side. A maximum of four curves is possible: cervical or cervicothoracic, thoracic, thoracolumbar or lumbar, and lumbosacral.

FIG. 12

Roentgenogram showing a lumbar curve compensated by a lumbosacral curve and an oblique fifth lumbar vertebra.

A mid-thoracic primary curve is compensated by a lumbar curve (Fig. 8);
A high thoracic curve, by a cervicothoracic curve (Fig. 9);
A thoracolumbar curve, by a lumbosacral curve (Fig. 10);
A long thoracic curve, by a cervicothoracic and a lumbar curve (Fig. 11);
A lumbar curve, by a lumbosacral curve with oblique fifth lumbar vertebra (Fig. 12).

Results of Compensation-Derotation

The nature of the scoliosis determines the limits of correction. Although in all scolioses lateral deviation is combined with rotation on the convex side, the relative degree of the two deforming elements varies.

The inclinatory or contracture type, such as paralytic scoliosis, is much more easily compensated than the structural or collapse type. In this latter type, the translatory shift of the vertebrae indicates that they are not anchored in the costal cage, as in rachitic scoliosis. The lateral deviation, as well as the rotary element of the deformity, represents structural changes. Consequently, treatment of the inclinatory or contractural-type of scoliosis—early habitual or paralytic—will result in much better correction than will treatment of the collapse or structural type.

Finally, it must be realized that when the spine rotates, the thoracic cage does not follow it as one mechanical unit. It is more correct to say that the spine moves into the convex side of the thorax in both lateral

deviation and rotation. As the spinal column rotates, the thoracic cage is, more and more, left behind the much more rapidly rotating column, so that it actually remains on the concave side of the spinal curve. The usual attempt to correct the rib deformity by concave-side rotation is, therefore, inherently wrong, and can have no other effect than to accentuate the already existing disproportion between the spine and the thorax.

If compensation is obtained before the period of rapid growth, there is a tendency, during this period, for the curves to settle with an increase in angular values, though the compensation is not lost.

Method

If the sections of the spine beyond the curve are sufficiently pliable, the immediate effect of bending the trunk to the convex side is always the production of counter curves above and below the primary one. It is only secondarily that the primary curve is shortened and flattened according to the degree of its rigidity. Hence compensation becomes doubtful in cases of obliquity of the fifth lumbar vertebra; moreover, the compensation of the cervicothoracic or low lumbar curves is difficult. If a thoracic primary curve, with the tenth thoracic the transitional

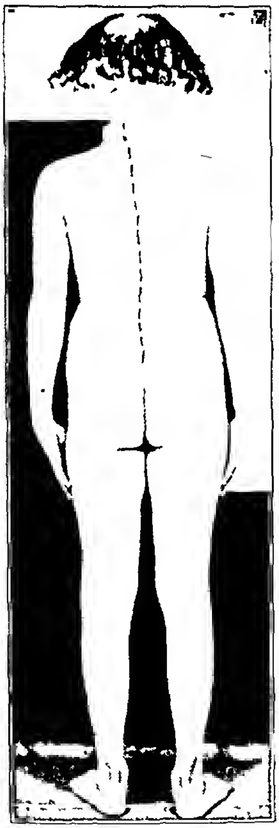

FIG. 13-A

FIG. 13-B

Photograph (Fig. 13-A) and roentgenogram (Fig. 13-B) illustrating adequate treatment of a habitual scoliosis by complete lumbar compensation in a patient with a thoracic primary curve, horizontal pelvis, and horizontal fifth lumbar vertebra.

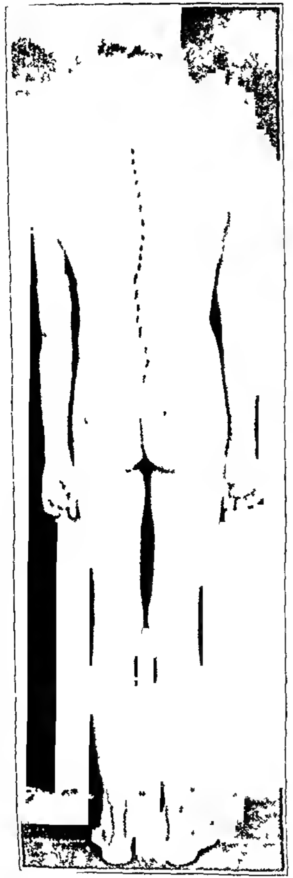

FIG. 14-A

FIG. 14-B

Photograph (Fig. 14-A) and roentgenogram (Fig. 14-B) illustrating adequate treatment of a habitual scoliosis by complete lumbar compensation in a patient with a primary thoracic curve, horizontal pelvis, and oblique fifth lumbar vertebra.

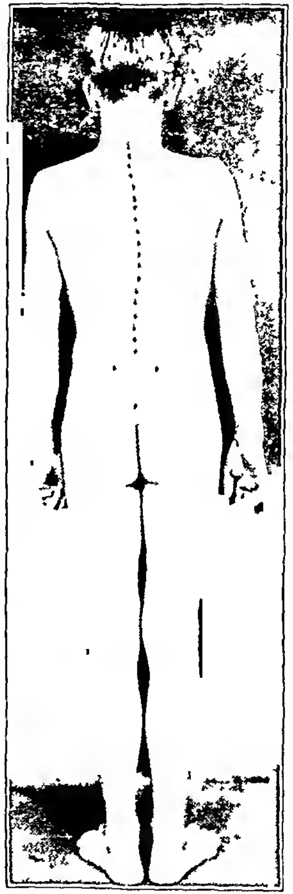

FIG. 15-A

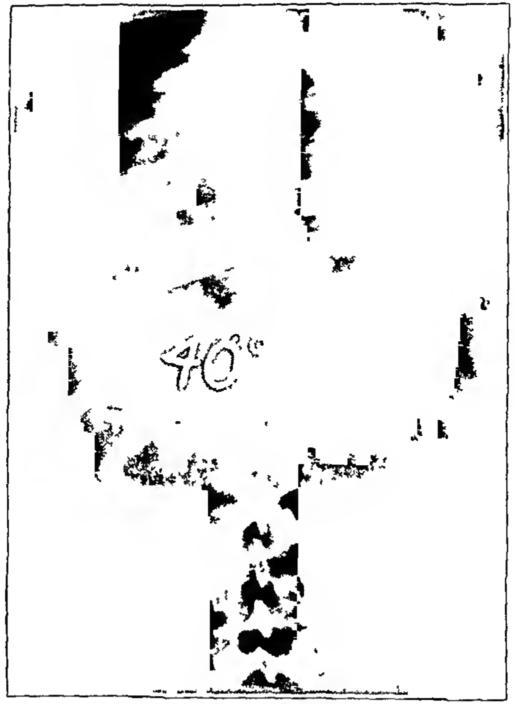

FIG. 15-B

Photograph (Fig. 15-A) and roentgenogram (Fig. 15-B) illustrating adequate treatment of a congenital scoliosis with a short moderate dorsal curve. The spine above and below the curve was straight, and the patient had passed the period of rapid growth.

vertebra, is not too long, both upper and lower counter curves may be adequately developed. In a thoracic primary curve, with the twelfth thoracic the transitional vertebra, the lumbar counter curve may be developed and complete compensation obtained. In a thoracolumbar primary curve, with the first lumbar the transitional vertebra, a lower lumbar curve may still be possible, except when there is an oblique fifth lumbar vertebra. A lumbar scoliosis with an oblique fifth lumbar vertebra progresses, and later may develop a secondary thoracic counter curve, but the maintenance of compensation without fusion is doubtful.

The compensation-derotation treatment consists in:

Equilibration of the Pelvis

The pelvis must be horizontal with its rotation corrected. Difference in the length of the extremities must be equalized (Figs. 13-A and 13-B).

Elimination of Weight-Stress

Pending the development of active muscle balance and the mobilization of the spine to develop adequate counter curves, the spine must be protected. This is done in the

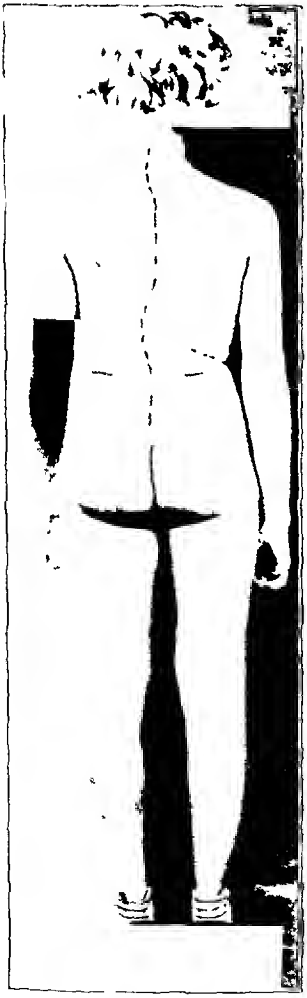

Fig. 16-A

Fig. 16-B

Photograph (Fig. 16-A) and roentgenogram (Fig. 16-B) illustrating adequate treatment of a congenital or rachitic scoliosis in a patient with a horizontal pelvis and horizontal fifth lumbar vertebra.

beginning by recumbency and traction, and later by mechanically adequate support. Mechanical adequacy of support implies: (1) a neck extension piece to control the spine above the eighth thoracic vertebra, and (2) a leg extension piece to secure the trunk against the pelvis.

FIG. 17

Roentgenogram showing a severe paralytic scoliosis which was compensated, but in which the compensation failed to hold

FIG. 18

Roentgenogram showing a rigid lumbar spine which could not be compensated

FIG. 19

Roentgenogram showing scoliosis in a patient with an oblique pelvis. Conservative treatment was inadequate.

FIG. 20

Roentgenogram showing a congenital high thoracic scoliosis which was not compensable

Mobilization of the Spine

Mobilization of the spinal sections adjacent to the primary curve by side-bending and derotation is undertaken for the purpose of developing alignment by compensatory curves. The passive mobilization is effected by side-bending and derotation manoeuvres already described on previous occasions.[1] Forcible compensation by a Risser cast commits one to subsequent fusion and is, therefore, to be reserved for prospective operative cases. It is certain that the development of counter curves and the shortening of the primary curve is better obtained by the corrective cast, but a spine so treated does not hold this correction of its own accord and, therefore, must be fused.

Fig. 21

Roentgenogram showing congenital scoliosis in a patient with an oblique pelvis and an oblique fifth lumbar vertebra for which conservative treatment was inadequate.

Development of Muscle Tone

Systematic development of muscle tone and improvement of the mechanical efficiency of the musculature by symmetrical and asymmetrical exercises are aimed at the active maintenance of correction. These exercises are especially designed to develop the long back and abdominal muscles, and to provide freedom and strength in the rotary movements of the shoulder girdle and pelvis. Compensation curves are developed automatically by the rotation of the shoulder girdle and pelvis in the direction opposite to the primary curve. The mechanical adequacy of these curves depends upon the nature, size, and degree of the primary curve, and upon the amount of pliability of the other sections of the spine from which the counter curves are formed. Maintenance of correction ultimately depends upon the active development of the tone of the back and shoulder muscles.

It is, therefore, necessary that muscle development keep step with the mobilizing methods. A brace is applied while the musculature is being developed to a state of mechanical sufficiency. The effect of this brace is not curative, but preventive. It is to safeguard, to enforce active correction and active maintenance of posture, and to prevent the progression of the curve by collapse.

Secondary decompensation may develop from muscular insufficiency, in one of two ways: Either, the primary curve may extend upward into the cervicothoracic section, with an overhang of the head on the concave

side and a secondary readjustment of the head over the pelvis by shifting the trunk toward the convex side; or it may extend downward into the lumbar compensatory curve, with a total shift of the trunk toward the convex side:

During the ambulatory period the brace provides against the former event through its neck piece, and against the latter through its thigh piece.

CRITERIA OF MUSCLE SUFFICIENCY

1. Standing and recumbent lengths of the thorax are the same.
2. Distensibility of the spine is diminished.
3. Posture is maintained actively, permanently, and without effort.
4. Normal sense of thoracic equilibrium is restored.

INDICATIONS AND CONTRA-INDICATIONS

The compensation-derotation treatment is adequate when the following conditions are present:

1. Complete lumbar compensation of a thoracic primary curve with horizontal pelvis and horizontal fifth lumbar vertebra, as in a habitual scoliosis with a moderate curve (Figs. 13-A and 13-B).

2. Complete lumbar compensation of the thoracic primary curve with horizontal pelvis, but oblique fifth lumbar, as in a non-paralytic scoliosis, with a straight upper thoracic spine and a moderate curve (Figs. 14-A and 14-B).

3. A short and moderate thoracic curve with a straight upper and straight lumbar spine, as in a congenital or habitual scoliosis in a patient who has passed the period of rapid growth (Figs. 15-A and 15-B).

4. A primary lumbar curve, with a horizontal pelvis and a horizontal fifth lumbar, as in a rachitic or congenital scoliosis (Figs. 16-A and 16-B).

The compensation-derotation treatment is inadequate in the following cases:

1. All paralytic cases, with possibly a few exceptions of the mildest types (Fig. 17).

2. Severe cases of all ages and types, which, because of a rigid lumbar spine, remain uncompensated (Fig. 18).

3. All scolioses with oblique pelvis, except those in patients close to the completion of growth (Fig. 19).

4. All high thoracic or cervicothoracic curves, not completely compensable. There are, however, some congenital high thoracic and cervicothoracic cases with congenital fusion which hold after conservative treatment (Fig. 20).

5. Congenital scoliosis with oblique pelvis and oblique fifth lumbar (Fig. 21).

RESULTS OF TREATMENT

Eighty per cent. of our patients were treated conservatively and only 20 per cent. were operated upon.

Of these, one hundred cases treated conservatively by the compensation-derotation method, were selected on the basis of completeness of record and time of observation. All had five years or more of post-treatment observation. The types of these scolioses were distributed as follows:

Habitual	69
Paralytic	14
Rachitic	7
Congenital	10
	100

Sixty-four of the spines were mobile and thirty-six rigid at time of the examination. Spontaneous compensation had occurred at that time in thirty cases, of which twenty-four were habitual, three congenital, two rachitic, and one paralytic. Complete compensation was obtained by treatment in fifty cases, incomplete or no compensation in twenty cases.

As a result of this type of treatment the correction held in eighty cases and failed in twenty.

Nine of the failures were paralytic cases, which indicates an error in selection. It should be noted that of the twenty cases which could not be adequately compensated, only one held; the others failed.

All cases of spontaneous compensation held in the presence of good musculature. No attempt was made to correct the primary curve except in five of these cases, and they finally lost their compensation and failed because of inadequate musculature; the rest were kept under careful observation, proper support, and development of the musculature, and remained compensated.

Paralytic and severe structural non-paralytic scolioses did not respond to conservative treatment alone and in these patients, who are not considered in this series, the spine had to be fused. An increase in the primary curve took place under conservative treatment in individuals before or early in the period of rapid growth, but not in older patients. However, this did not mean a break in compensation or loss of posture.

A later series of twenty-one cases, treated conservatively by the combined derotation-compensation method with a follow-up of two years or more, gave the following results:

Four, or 19 per cent. of the patients were compensated on admission, and were treated by support and muscle development only; all of them maintained the correction.

Seventeen, or 81 per cent. were not compensated at admission, and were treated by manipulative correction, derotation, muscle development, and support. The average period of time necessary to obtain complete

compensation was eight months. Of these seventeen, only one patient with a congenital scoliosis and a hemisacralization of the fifth lumbar failed to respond.

In this series twenty cases, or 95 per cent., held their correction, and one, or 5 per cent., failed to do so.

There were no paralytic cases in this series and only two congenital. The improvement of results over the former series (95 per cent. versus 80 per cent.) is due to the better selection of cases.

CONCLUSIONS

1. Compensation of the scoliosis is a necessary prerequisite for maintenance of correction and posture.
2. The combined compensation-derotation method is adequate to obtain compensation in suitable cases and leads to definite maintenance of posture.
3. The rotary deformity of the thoracic spine cannot be corrected at present. Attempts to correct the thoracic deformity by rotation to the concave side are preposterous. The thorax is already rotated to the concave side in relation to the spinal column, and such attempts only make the situation worse.
4. Derotation is directed toward the lumbar and cervicothoracic section of the spine, and, by limbering up these sections, aids in the development of adequate counter curves.
5. If the compensation can be accomplished without forcible cast correction, and provided muscle development is adequate, the spine need not be fused. However, if the compensation must be forced by a cast, fusion will become necessary to hold the correction obtained.
6. Failure must be expected, with or without fusion, when compensation is lost or not obtained. Only a few cases at the end of the growth period hold the correction when decompensated.
7. Failure must also be expected in the absence of adequate muscle development, unless fusion is performed.
8. Compensation-derotation plus adequate muscle development promises success in the great majority of all non-paralytic cases.
9. Adequate compensation-derotation plus fusion in the presence of inadequate musculature, likewise, holds out promise of success in all paralytic and many congenital cases.

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TREATMENT OF GAS GANGRENE EXPERIMENTALLY PRODUCED

BY GUY A. CALDWELL, M.D., NEW ORLEANS, LOUISIANA

Since 1892 when Welch[11] first described the bacillus later given his name, persistent efforts have been directed toward controlling the infection by medicinal agents, antitoxins, roentgen-ray therapy, and surgical measures. Recent experimental work on mice indicates that *p*-aminobenzenesulfonamide (sulfanilamide) has definite bacteriostatic action against Welch's bacillus. That patients with gas gangrene have shown improvement and even recovery following the administration of sulfanilamide is clinical evidence supporting such studies[1]. Jensen and his coworkers[5] were able to reduce considerably the incidence of gas gangrene associated with compound fractures when this drug was implanted in the débrided wound. Because few pyogenic infections develop in compound wounds débrided and treated with sulfanilamide, it was believed safe to close most of them without drainage. Closure of wounds communicating with fractures and contaminated by organisms producing gas gangrene was previously considered dangerous[2,3]. It, therefore, has become important to determine accurately whether débrided wounds implanted with sulfanilamide may be closed without fear of further progress of the infection.

Bliss and Long[8] in a report of their experimental work state, "Recently we have noted that sulfanilamide has a curative effect in mice infected with Clostridium welchii. Studies made on the peritoneal exudates of treated and untreated mice have been of great interest. . . . The inoculum was prepared. . . . Then 0.5 c. c. of this suspension was inoculated by the intraperitoneal route into test mice. . . . At six hours and fifteen minutes after infection all three control mice were dead of toxemia, while the treated mice were well on the way to recovery. . . . The results of these and other similar experiments with Clostridium welchii seem to indicate that as far as this particular organism is concerned sulfanilamide acts primarily by reducing the rate of multiplication of the organisms in the peritoneal cavity of the infected animals. In other words, the chemical has a bacteriostatic action in vivo as well as in vitro."

These experiments, indicating that sulfanilamide acts primarily by reducing the rate of multiplication of the organisms in the peritoneal cavities of infected animals, suggested that *when the clostridia are propagating more rapidly*, as they do in devitalized muscles[10], *the effect of the drug might not be so curative.* Kendrick[7] was the first to report experiments in which gas gangrene was induced primarily in the muscles and treated with sulfanilamide. Since most clinical cases occur in the muscles surrounding compound fractures, accurate evaluation of the efficacy of the drug can be made only by experimentally producing a compound fracture, using Welch's bacillus, and then treating the animal with sulfanilamide.

Because several clinical reports [4,6] in recent years have shown that roentgen-ray therapy arrests the progress of gas gangrene and no satisfactory experimental work has been carried out to substantiate this theory, it was decided to induce gas gangrene in the muscles of guinea pigs and subject them to irradiation.

The Welch's bacillus is an obligatory anaerobe which propagates slowly with little tendency to invade tissue in the presence of adequate amounts of oxygen. Many oxidizing agents have, therefore, been tried, but found relatively inefficacious when the infection occurs in deep wounds of the muscles. Recently, Meleney and Johnson[9] have found, however, that a paste made from zinc peroxide emits oxygen slowly over a period of twenty-four hours. They were able to destroy various anaerobes by placing this paste in crater-like wounds containing these organisms. No experiments have been reported in which zinc peroxide has been implanted in wounded muscles infected with Welch's bacillus. Experiments were, therefore, planned to determine whether zinc peroxide would prevent the development of gas gangrene in compound fractures.

PLAN OF THE EXPERIMENTS

Guinea pigs were selected for the experiments because of their susceptibility and because their bones are large enough to permit drilling several holes in the cortices of their femora. Since it is not practical to splint and dress the fractured bones of guinea pigs, the marrow cavity was exposed to infection by drilling multiple holes through the outer cortex, thus producing the counterpart of a compound fracture which did not necessitate splinting. A transplant of the strain of the Welch's bacillus employed by Bliss and Long [8] in their experimental work on mice was obtained. Its morphological and cultural characteristics were verified and further transplants then used throughout the experiments.

Each guinea pig was anaesthetized with ether and a short incision was made on the outer side of the right thigh. The fascia and muscles were split and retracted, and drill holes were made in the cortex of the femur. The muscle fibers were then cut transversely in several places and crushed with a hemostat. Amounts of a twenty-four-hour broth culture of the Welch's bacillus, varying from 0.15 to 0.3 cubic centimeters were dropped into the wound (not injected into the body of the muscles). The incision was then sutured with continuous silk, and, after intervals of from one to six hours, various treatments and surgical measures were instituted.

Implantation of Sulfanilamide Crystals

Nineteen guinea pigs were prepared as described above. At intervals of from one to six hours after the inoculations, débridements were done, but the wounds were not irrigated. Fifteen to 30 milligrams of sulfanilamide crystals were then sprinkled over the surfaces of bone and muscles, and the wounds were sutured.

Results. Of these nineteen animals, fifteen died after six to forty-eight hours and the other four lived. Eight controls, inoculated only, died after fourteen to eighty-six hours. Four controls to determine the effect of operative trauma, anaesthetics, and toxicity of the drug, lived.

Intraperitoneal Injections of Sulfanilamide

A second series of experiments was undertaken to determine whether intraperitoneal injections of sulfanilamide would prevent the development of gas gangrene when the infected wounds were débrided, irrigated with saline solution, and left open. Two hours after the inoculation of the wound, a débridement of the skin, fascia, and muscles was done, followed by irrigation of the wound with saline solution. Immediately after this procedure, 50 milligrams of sulfanilamide were given intraperitoneally and repeated every six hours until the animal either expired or had lived forty-eight hours.

Results. Of nine animals thus treated, seven lived and two died after twelve hours. Control experiments on ten animals carried out with slight variations resulted in the death of eight after eighteen to ninety-six hours, and the survival of only two.

Implantation of Zinc Peroxide

Wounds were infected with Welch's bacillus as in the preceding experiments. After two hours these were débrided, irrigated with saline, and a thin paste made of zinc peroxide after the method of Meleney [9], was poured into the wound and retained by suturing the skin. After forty-eight hours, the wounds were opened, remnants of the paste were removed by irrigations with saline, and the wounds were left open.

Results. Four of the five animals lived, the other died; two animals, inoculated only, died in thirty-six hours. The four animals that survived developed moderate swelling of the thighs for twenty-four hours, did not appear ill, and never had the clinical evidences of gas gangrene. The animal that died had gas gangrene, but upon opening the wound it was found that the paste of zinc peroxide remained waxy, firm, and brownish in color, whereas in all the other animals it had changed into hard, white crystals of zinc oxide.

Roentgen-Ray Therapy

To determine the effect of roentgen rays upon the development of gas gangrene, two series of experiments were performed. The first group of animals was so traumatized and infected as to produce a fulminating type of infection ending in death of the controls at twelve to fourteen hours. The second group with less trauma and smaller numbers of organisms had less severe infections resulting in death of the controls after forty-eight to seventy-two hours. To estimate accurately the value of roentgen rays in combatting gas-gangrene infection, this group of animals received no treatment except roentgen therapy. The first

group was given 100 to 200 roentgen units one to three hours after the inoculation.

Results. Of ten animals thus treated, three lived and seven died after eight to eighteen hours. Four controls, similarly inoculated but not treated, died after twelve to seventy-two hours. All three of the surviving animals had the clinical manifestations of gas gangrene during the first forty-eight hours; the process then became localized, the gas and oedema disappeared, and there appeared extensive areas of dry necrosis of the skin followed by deep sloughing into the muscular layers.

SUMMARY

An effort has been made to produce experimentally, in guinea pigs, the counterpart of a compound fracture infected with a lethal number of Welch's bacilli, and to treat these in some of the various ways suggested by clinical and laboratory observations.

Débridement of the wounds followed by implantation of 15 to 30 milligrams of sulfanilamide crystals and closure resulted in the survival of only four of nineteen animals.

Débridement and irrigation of similar wounds left open, and followed by the administration of 50 milligrams of sulfanilamide intraperitoneally every six hours, resulted in the survival of seven of nine animals.

Débridement and irrigation of such wounds followed by implantation of zinc peroxide paste and suture of the wounds resulted in the survival of four of five animals.

Wounds similarly produced and sutured and treated with roentgen rays in varying dosage at different intervals were followed by death in seven of ten animals.

CONCLUSIONS

As far as can be determined by experiments in which a crude counterpart of a compound fracture infected with Welch's bacillus has been produced in the thighs of guinea pigs, the following observations are correct:

1. Sulfanilamide crystals implanted in such infected wounds after débridement seldom control or prevent the development of gas gangrene.
2. Administration of large doses of sulfanilamide by intraperitoneal injection after the wound has been débrided, irrigated, and left open precludes the development of gas gangrene in a high percentage of cases.
3. Implantation of zinc peroxide paste in débrided wounds prevents the development of gas gangrene in most instances.
4. Roentgen-ray treatment has no effect upon the progress of a fulminating type of gas gangrene, but does bring about some localization of the process when given one to two hours after inoculation, and when the animals survive forty-eight hours and longer.
5. The bacteriostatic effect of sulfanilamide upon Welch's bacillus injected into the abdomen is not duplicated when the same organisms are planted in traumatized muscular tissue.

6. Further experiments should be carried out to confirm these conclusions, and others to ascertain whether combinations of zinc peroxide paste in the wound and sulfanilamide given orally or intraperitoneally may not be more effective than either of them alone.

Experiments were carried out in the laboratories of the Touro Infirmary with the advice and valued assistance of the late John A. Lanford, M.D., Assistant Professor of Pathology and Bacteriology, and Meyer D. Teitelbaum, M.D., Instructor in Radiology, Tulane University of Louisiana, School of Medicine. Their sincere interest and help are gladly acknowledged and greatly appreciated.

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SURGICAL APPROACH TO THE PROXIMAL END OF THE RADIUS AND ITS USE IN FRACTURES OF THE HEAD AND NECK OF THE RADIUS

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The approach to the radial head and neck is not considered very difficult, because the head is rather superficially located and may appear easily accessible. However, in spite of its apparent ease and accessibility, there are important anatomical structures which change position with pronation and supination of the forearm. The change in the relative position of these structures with pronation and supination is very important and must be known to avoid serious injury to the branches of the radial nerve.

A preliminary anatomical study was made of this region with the intention of establishing: first, the relationship of the branches of the radial nerve to the lateral epicondylic ridge of the humerus; and, second, the relationship of the posterior branch of the radial nerve to the neck of the radius, when the forearm is placed in pronation and supination. The relationship of the branches of the radial nerve to the epicondylic ridge is important, because the exposure of the radial head can be made very much more satisfactorily if the surgical incision is extended about an inch and a half above the humeral epicondyle. The relationship of the posterior branch of the radial nerve to the neck of the radius is of utmost importance, because this branch recedes about one inch from its position in supination to its position in pronation.

In the study of the relationship of the branches of the radial nerve and muscles to the lateral epicondylic ridge of the humerus, the following structures are involved: the brachioradialis, the extensores carpi radialis longus and brevis, the lower end of the triceps brachii, the anconeus, the extensor digitorum communis, and the supinator radii brevis, and their nerve branches. It was noticed in the course of the study, that the nerve supply to the brachioradialis comes through a branch which emerges from the radial nerve, anterior to the epicondylic ridge about two and a half inches above the epicondyle. This branch divides into several smaller twigs which enter the deep surface of this muscle. The nerve of the extensor carpi radialis longus is given off about an inch more distal, also in front of the epicondylic ridge, and enters the muscle slightly above the epicondyle on the deep muscular surface. The nerve of the extensor carpi radialis brevis is often found crossing the epicondylic ridge from behind forward, emerging from the posterior branch of the radial nerve about one inch lower than the branch to the extensor carpi radialis longus. Sometimes the nerve to the extensor carpi radialis brevis appears to come

from the anterior division of the radial nerve. The nerve of the anconeus is given off very much higher in the posterior compartment of the arm. It is a branch of the inferior nerve of the medial head of the triceps brachii and it runs far behind the lateral epicondylic ridge. The supinator radii brevis receives its supply from the posterior branch of the radial nerve in its course through the supinator radii brevis muscle. The extensor digitorum communis and the other extensor muscles of the forearm are supplied by the posterior branch after its emergence from under the lower border of the supinator radii brevis muscle. Thus, an incision placed along the lateral epicondylic ridge and continued distally between the extensor radialis brevis and the extensor digitorum communis, will completely avoid all the important nerve branches to muscles in this region.

Several surgical approaches have been recently proposed. Boyd's approach consists in completely separating the anconeus and the supinator radii brevis from their ulnar insertion and then retracting the entire mass, including the posterior branch of the radial nerve, externally. This incision was found convenient in cases where the entire upper third of the radius and the ulna had to be exposed. However, when only the head of the radius has to be approached from the ulnar side, the radius is found deeply situated and more difficult to reach. A very good approach was described by Cadenat. He placed the incision between the extensores carpi radialis longus and brevis. It is known that it is easy to separate those two muscles at the level of the elbow, and, by separating them, easy to expose the posterior branch of the radial nerve as it enters the supinator radii brevis. In this manner, the preliminary exposure of the posterior branch avoids injury to this nerve. In making this incision it was found that the exposure of the head of the radius between the two radial extensors of the wrist made it more difficult to reach the head, and might also lead to injury of the nerve of the extensor radialis brevis, since this muscle often receives its nerve supply from the anterior branch of the radial nerve. Key and Conwell advise a straight lateral incision between the brachioradialis and the extensor carpi radialis longus. This approach may endanger the nerve supply to the extensores carpi radialis longus and brevis, if the incision is extended proximally.

In the anatomical study of a safe incision to the head and neck of the radius, the posterior branch of the radial nerve was exposed and its position in pronation and supination noted. Figure 1 illustrates the elbow, exposed through an incision running along the lateral epicondylic ridge, then through the posterior part of the lateral ligament of the elbow joint and through the orbicular ligament, down to the space between the extensor carpi radialis brevis and the extensor digitorum communis. This incision, with the forearm in supination as shown in the insert, is made posterior to the brachioradialis and the extensores carpi radialis longus and brevis, and avoids the nerve branches supplying these muscles. For simplification, the posterior motor branch of the radial nerve and the anterior sensory nerve are presented more prominently than they are in

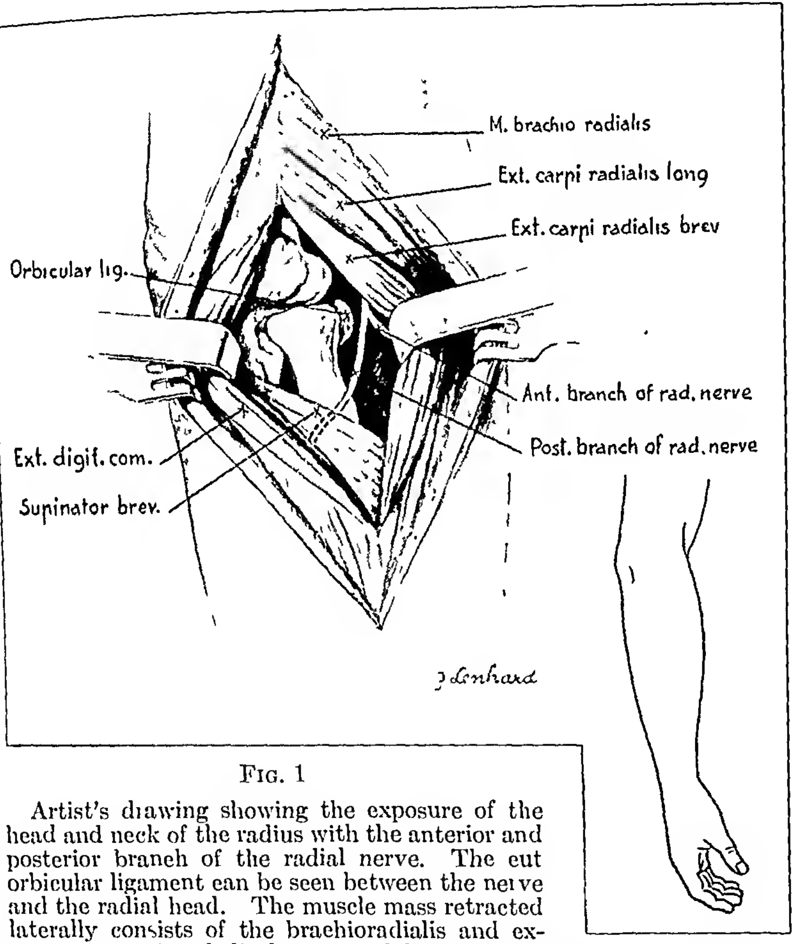

FIG. 1

Artist's drawing showing the exposure of the head and neck of the radius with the anterior and posterior branch of the radial nerve. The cut orbicular ligament can be seen between the nerve and the radial head. The muscle mass retracted laterally consists of the brachioradialis and extensores carpi radialis longus and brevis. The medial mass contains the extensor digitorum communis. The oblique fibers seen in the depth of the wound represent the supinator radii brevis. Note the relation of the posterior branch to the head and neck of the radius, the forearm being in supination, as shown in the insert.

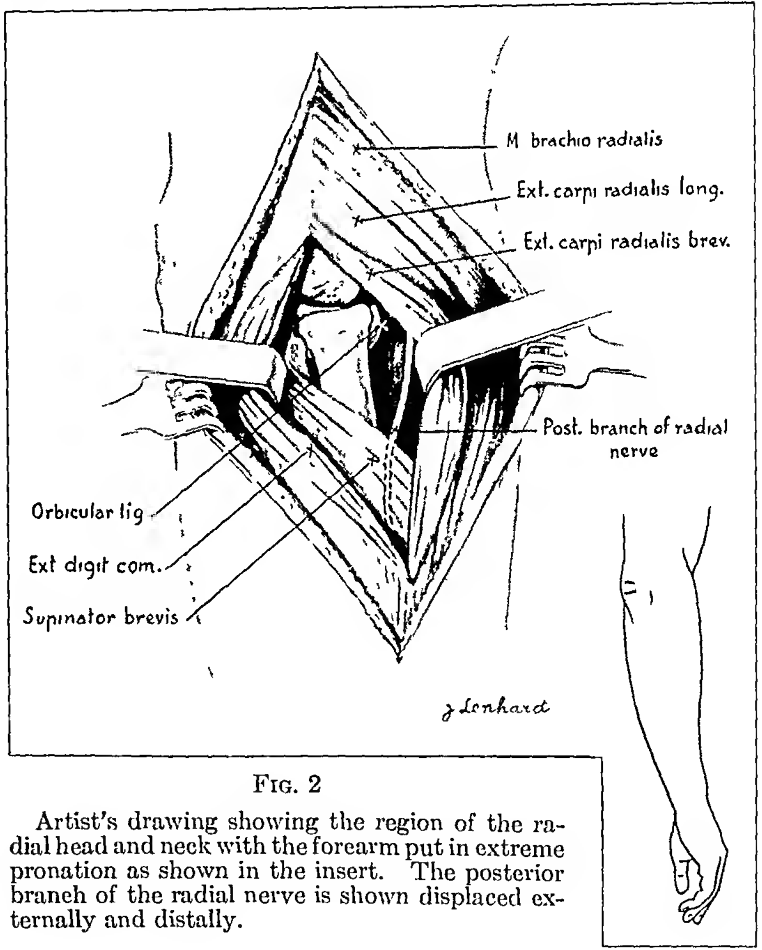

FIG. 2

Artist's drawing showing the region of the radial head and neck with the forearm put in extreme pronation as shown in the insert. The posterior branch of the radial nerve is shown displaced externally and distally.

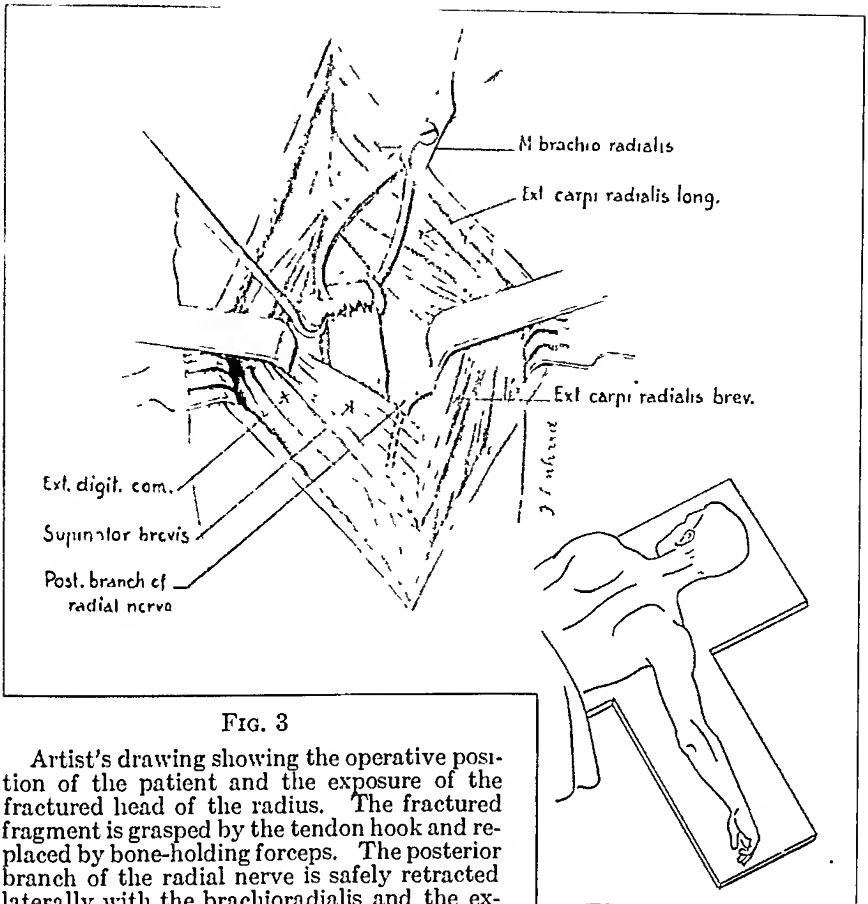

Fig. 3

Artist's drawing showing the operative position of the patient and the exposure of the fractured head of the radius. The fractured fragment is grasped by the tendon hook and replaced by bone-holding forceps. The posterior branch of the radial nerve is safely retracted laterally with the brachioradialis and the extensores carpi radialis longus and brevis.

reality to show clearly the relation of the motor branch to the radial head and neck. Figure 2 shows the same exposure, but with the forearm placed in complete pronation as shown in the insert. It can be seen that in pronation the posterior branch of the radial nerve becomes more distal in relation to the head of the radius and more external in relation to the neck. With these facts in mind it is not necessary to look for and expose the posterior branch of the radial nerve when a surgical incision is made. It is only necessary, with the forearm kept in complete pronation, to avoid placing the incision more than two inches below the articular surface of the head of the radius externally, and two and three-quarters of an inch below the same surface posteriorly.

The author's anatomical study of the approach was made in conjunction with treatment of fractures of the head of the radius in children, where, according to accepted opinion, replacement of the head is considered best.

OPERATIVE PROCEDURE

In the operative procedure developed on the basis of the anatomical study, the patient is placed, as shown in the insert (Fig. 3), in a prone posi-

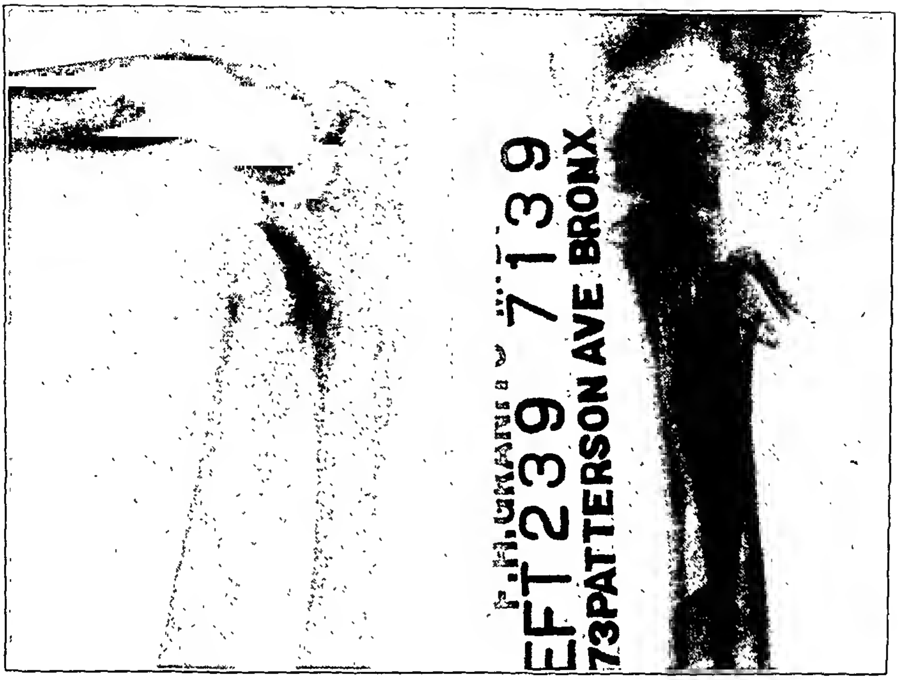

Fig. 4-A Fig. 4-B

Anteroposterior and lateral roentgenograms of a fracture of the neck of the radius with lateral and anterior displacement.

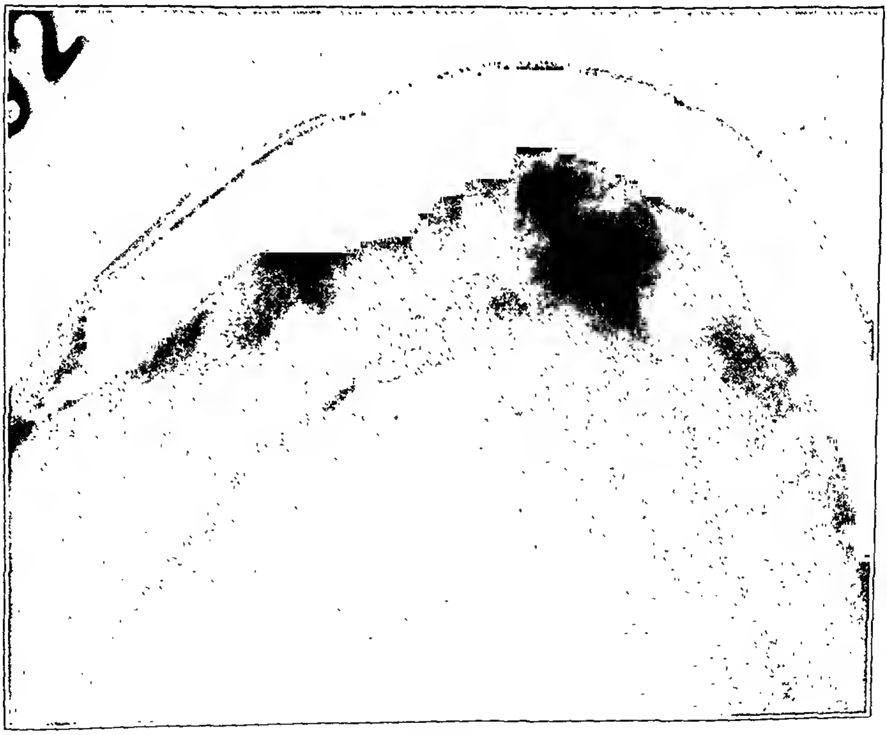

Fig. 4-C

Roentgenogram showing immediate postoperative reduction.

tion with the forearm in complete pronation, so that the little finger points upward. In this position, an incision is made over the lateral aspect of the elbow, starting directly over the epicondylic ridge about one and one-half inches above the epicondyle and extending the incision proximally for about two inches below the line of the radiohumeral joint. The incision is carried right down to the bone between the brachioradialis and the two radial extensors of the carpus laterally, and the extensor digitorum communis medially. The first mass of muscles is retracted laterally and the extensor digitorum communis is retracted medially. The supinator radii brevis muscle is identified in the depth. The radial neck and head are exposed. At this stage of the operation it is usually found that the fractured head is displaced forward, and that it is very difficult to grasp and extract it from the depth. A tendon hook can be used to catch the fractured surface of the displaced head and bring it sufficiently near the surface for a bone-holding forceps to secure it. As soon as the head is caught in this position, it is easy to replace it on the fractured neck, and to impact it firmly. Once the head is placed in this position, flexion and extension of the forearm, as well as pronation and supination, do not seem to displace it. The soft tissues are then sutured over the replaced head, and the arm is immobilized in a position of flexion and supination, for a period of two to three weeks.

Mayer has stated that, for operation on the head of the radius, the prone position of the patient with the forearm in complete pronation, and

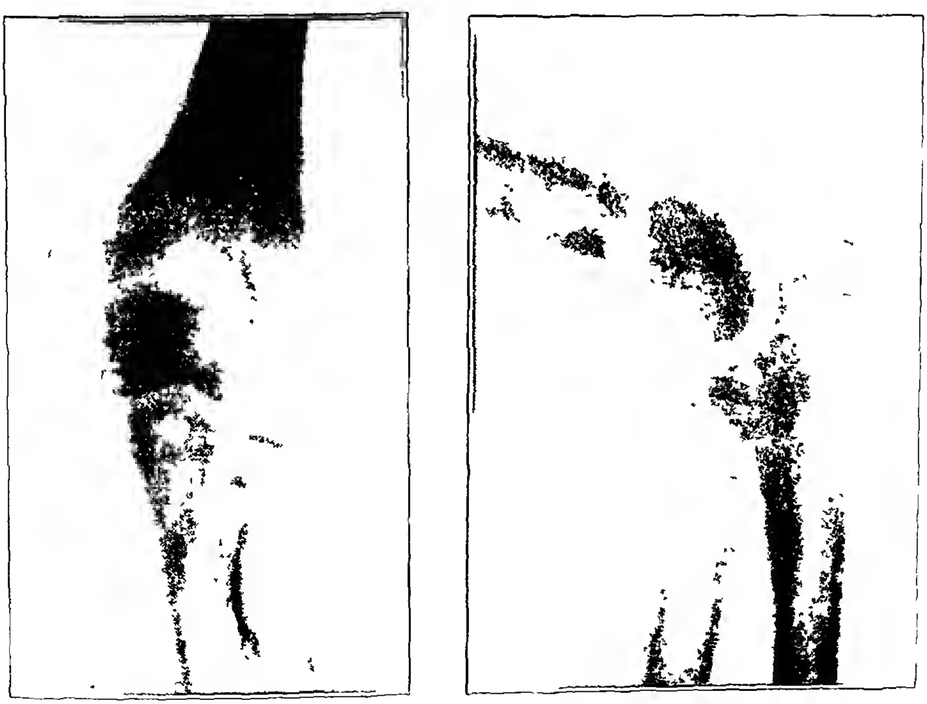

Fig. 4-D

Fig. 4-E

Anteroposterior and lateral roentgenograms taken ten months after operation.

the incision placed as described above, has been used by him with great satisfaction for the past several years.

ILLUSTRATIVE CASE HISTORY

A fourteen-year-old boy (No. 77714) admitted to the hospital on July 6, 1939, fell six days before onto a concrete ledge of a swimming pool and injured his left elbow. The elbow became swollen, flexion and extension almost impossible, and supination and pronation very painful. Roentgenograms (Figs. 4-A and 4-B) showed a fracture of the neck of the radius below the epiphyseal plate. The head was displaced externally and slightly forward and was out of contact with the humerus. On this date, through an incision made over the external aspect of the elbow the head was replaced, the orbicular ligament sutured, and the forearm immobilized in a posterior splint for three weeks. Postoperative roentgenogram (Fig. 4-C) showed good realignment. Subsequent examination on May 22, 1940, ten months after the operation, showed a good anatomical result (Figs. 4-D and 4-E). Functionally the elbow was normal, the carrying angle was normal, pronation and supination were complete; flexion and extension of the elbow were equal to the normal side, and no atrophy of the muscles could be seen.

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SPINAL EXTRADURAL CYST ASSOCIATED WITH KYPHOSIS DORSALIS JUVENILIS *

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Non-parasitic, extradural, spinal cysts are so rarely encountered that when Elsberg, Dyke, and Brewer, in 1934, presented four cases found among 250 records of spinal tumors they believed that their report on this condition was the first published. This was closely followed by an extremely interesting paper by Lehman, who found three cases, previously reported by Schlesinger in 1898, Krauss in 1907, and Mixter in 1932, and added two cases of his own.

It remained for Cloward and Bucy in 1937 to correlate the presence of these cysts with the well-known deformity of the adolescent thoracic spine, kyphosis dorsalis juvenilis. The latter condition, long recognized as Scheuermann's disease, or occupational or apprentices' scoliosis, has been referred to commonly as vertebral epiphysitis, without any real evidence to indicate the underlying pathology. Cloward and Bucy demonstrated that, with one exception, all reported cases of extradural cysts of the spinal cord, which gave rise to symptoms during adolescence, were associated with deformities of the thoracic spine, usually a kyphosis of the type seen in Scheuermann's disease. The presentation of these authors leaves little doubt as to the relationship which exists between these benign extradural cysts and the associated vertebral condition, and makes a distinct contribution to the pathology of kyphosis dorsalis juvenilis. Aside from clearing up a difficult and vaguely understood condition, the thesis of these authors takes its place in modern medicine as an example of brilliant clinical reasoning.

Schanz and Scheuermann were among the first to describe the kyphotic deformity, seen in adolescents, which is almost always limited to the dorsal spine, and is rounded in type because of the partial collapse of several contiguous vertebral bodies. The process is self-arresting. The characteristic changes in the vertebral bodies are confined to the anterior part of the superior and inferior surfaces with a stepladder notching arrangement which may become wedge-shaped in the later stages. If allowed to progress, the condition becomes fixed, and may not be changed during the life of the patient. It was thought originally that the disease was a form of vertebral epiphysitis, although no direct evidence of such primary involvement could be demonstrated. The most rational explanation, to date, is that advanced by Cloward and Bucy. They believe

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† Neurosurgical Service of Carl W. Rand, M. D.

TABLE I
Recorded Cases of Spinal Extradural Cysts

Case No.	Date Reported	Author	Age	Duration of Symptoms	Sex and Color	Location of Cyst	Dilatation of Spinal Canal	Results and Comments
1	1898	Schlesinger	?	?	?	Mid-thoracic	?	Patient died from multiple sclerosis. Postmortem findings
2	1907	Krauss	46	13½ months	M.	3rd to 6th thoracic	?	Progress of disease arrested, but patient a helpless invalid
3	1932	Mixter	26	13 years	M.	3rd to 7th thoracic	?	No improvement
4	1934	Elsberg, Dyke, Brewer: Case 1	12	3½ years	M.	5th to 12th thoracic	Present (x-ray)	Great improvement, but not complete cure; previous scoliosis much more marked
5	1934	Elsberg, Dyke, Brewer: Case 2	15	3 months	M.	6th to 9th thoracic	Present (x-ray)	Cure
6	1934	Elsberg, Dyke, Brewer: Case 3	15	9 months	M.	4th to 9th thoracic	Present (x-ray)	Slight improvement
7	1934	Elsberg, Dyke, Brewer: Case 4	16	2 years	F.	Mid-thoracic	?	Almost complete cure
8	1935	Lehman: Case 1	12	3½ months	M. C.	6th to 8th thoracic	Present (Operation)	Cure; kyphosis
9	1935	Lehman: Case 2	17	9 months	M. C.	6th to 10th thoracic	?	Cure; kyphosis
10	1936	Cloward	43	2 years	M. W.	10th thoracic to 5th lumbar	Present (x-ray)	Almost complete cure
11	1936	Peet and Kahn	12	2 months	F. W.	9th thoracic to 4th lumbar	Present (Operation)	Cure
12	1937	Kelly	15	5 months	M.	6th to 8th thoracic	Present (x-ray)	Cure
13	1937	Cloward and Bucy	20	6 years	M. W.	7th to 9th thoracic	Present (x-ray)	Almost complete cure
14	1937	Mayfield and Spurling *						
15	1937	Teachenor *						
16	1939	Robertson and Graham	14	6 months	M. C.	7th to 9th thoracic	Present (x-ray)	Cure
17	1941	Adelstein	15	5 months	F. W.	5th to 7th thoracic	Present (x-ray)	Cure; previous kyphosis increased

* Quoted by Cloward and Bucy.

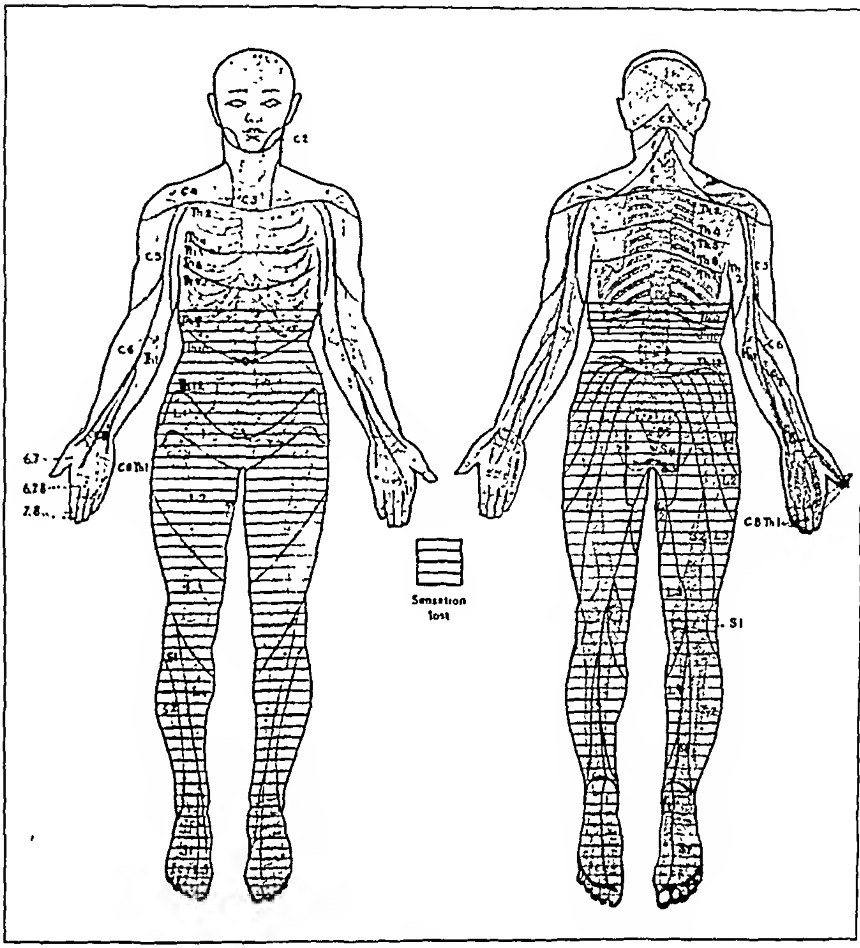

FIG. 1

Diagram shows the loss of cutaneous sensation below the eighth thoracic dermatome.

the kyphosis associated with extradural cysts is due to impaired venous drainage of the vertebral bodies from compression of these channels by the cysts. The cysts themselves are explained as congenital diverticulae of the dura and arachnoid at the exit of a spinal root.

To date, sixteen cases of this syndrome have been recorded (*Table I*). Since these patients, in the main, respond favorably to surgical intervention, the need for early recognition must be emphasized. The case presented here has been followed for over two years and demonstrates that early intervention with removal of the extradural cyst may result in complete cure with apparent arrest of the kyphotic deformity.

CASE REPORT

M. C., No. 547–931, a fifteen-year-old Mexican girl, was admitted to the Neurological Service of the Los Angeles General Hospital on July 2, 1937, complaining of severe weakness in both lower extremities with loss of bladder control. Some five months prior to the hospital admission she had first noticed beginning weakness in her legs, starting in the left foot. At no time had there been any pain or disturbed sensation in the form of tingling

or paraesthesia. During the month of June, 1937, walking became so difficult that patient could take but a few steps at a time. The family had noted that the child was rapidly becoming round-shouldered and had attempted to correct her posture by constantly advising her to stand erect. At the time of hospital admission the child could no longer walk without support.

The history otherwise was quite negative. The child had always enjoyed good health with no past history of any serious ailments, operations, or accidents.

Examination revealed a slender girl with a marked degree of rounded kyphosis of the mid-thoracic spine. The cranial nerves were entirely normal, and the upper extremities presented normal strength and intact sensation. There was a marked spastic paraplegia with little or no strength in the lower extremities and patient could scarcely move either leg up off the bed for even a short distance. Below the level of the eighth thoracic segment there was a loss of sensation of pain (Fig. 1). Position and vibratory sensibilities were entirely absent below the twelfth dorsal dermatome.

The lower tendon reflexes exhibited marked hyperactivity and there were bilateral Babinski signs as well as the associated Gordon, Oppenheim, and Chaddock signs. Ankle clonus was obtained on both sides. The patient could not walk.

The spinal-fluid examination revealed an initial pressure of 80 millimeters of water. The Queckenstedt test, compression of the jugular veins, caused no perceptible rise in the manometer level even on bilateral compression. The fluid was clear but definitely xanthochromic, with a cell count of eleven lymphocytes and an increase in the globulin content by Pandy's test.

Fig. 2

Lateral roentgenogram shows marked kyphosis centering at the sixth and seventh thoracic vertebrae.

Roentgenographic examination revealed a curved kyphosis of the vertebral bodies in the mid-thoracic region centering at the sixth and seventh vertebrae (Fig. 2). This was associated with an irregular narrowing of the superior and inferior margins of the vertebral bodies anteriorly. The anteroposterior views indicated a narrowing of the pedicles of the fifth to the eighth thoracic vertebrae with definite spreading of the interpedicular spaces (Fig. 3). From the roentgenographic standpoint the condition was recognized as juvenile vertebral epiphysitis.

The diagnosis of a localized lesion at the level of the sixth dorsal vertebra was made, although the exact relationship of the roentgenographic findings to the possible underlying pathology was not appreciated at the time.

Operation

On July 19, 1937, a

laminectomy was performed, removing the spines and arches of the fifth, sixth, and seventh thoracic vertebrae. At the level of the sixth thoracic spine a large extradural cystic tumor was found, filling the spinal canal and extending easily two full segments. The upper and lower limits of this cyst were uncovered and the mass was gently peeled away from the dura. The entire tumor was found to be extradural with an apparent point of origin from the left, sixth, thoracic root. The dura was opened at this point to visualize clearly the relationships in this pathology. The left sixth thoracic root was cut, and the neck of the cyst was tied and divided at its exit in the corresponding intervertebral foramen. This allowed the removal of the cyst *in toto*. The dura was closed with one silk suture, and the rest of the wound closed in layers in the usual manner.

FIG. 3

Anteroposterior roentgenogram indicates marked spreading of the interpedicular spaces from the fifth to the eighth thoracic vertebrae.

Postoperative Course

The patient enjoyed an extremely smooth convalescence with rapid return of motor power in the legs. She was able to walk when she left the hospital, and has been kept under observation to date in the Neurological Out-Patient Department. She now appears to have completely recovered her motor and sensory powers in the lower extremities. The reflexes in the legs have remained rather hyperactive. The rounded kyphosis in the mid-thoracic region became somewhat more pronounced, but now appears to have reached its maximum degree of deformity, and has remained stationary for a number of months. The child has returned to school with no further difficulty.

Pathological Examination

Grossly, the specimen consisted of a saccular mass almost 4.5 centimeters in length (Fig. 4). To its surface was attached a small mass of fat. On opening the sac it was found to contain a blood clot and some fluid. The wall of the sac was thin but showed some variation in thickness.

Microscopically, section through the cyst wall showed loose connective tissue containing a few blood vessels (Fig. 5). No evidence of epithelial tissue could be determined. The diagnosis was made of an extradural cyst of undetermined etiology.

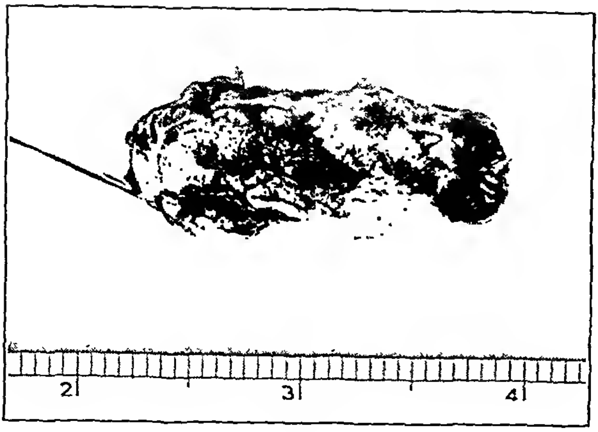

FIG. 4

Gross specimen of spinal extradural cyst after its removal from the mid-thoracic spinal canal. (Actual size.)

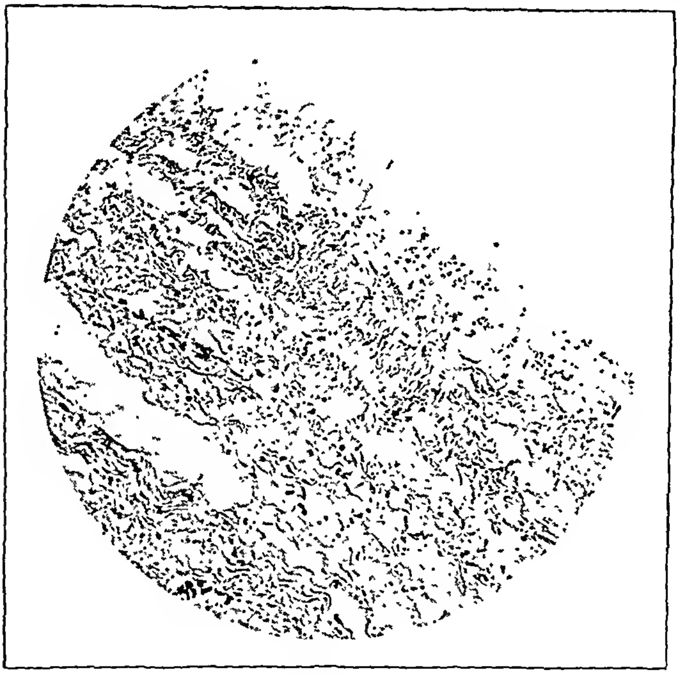

FIG. 5

Section through cyst wall showing loose connective tissue with a few blood vessels. There is no evidence of epithelial lining. (× 95.)

DISCUSSION

When Elsberg, Dyke, and Brewer published the records of their four cases in 1934, they were unable to find their counterpart in the literature up to that time. They outlined a characteristic syndrome of compression of the spinal cord by an extradural cyst including the following: *"The individual is an adolescent with the history and symptoms of a progressive spastic paraplegia. Pain is absent or is not a prominent symptom. The objective disturbances of sensibility are slight and their upper level is in the mid-thoracic region, usually at the sixth or seventh thoracic dermatome. The manometric tests demonstrate a subarachnoid block with the characteristic spinal fluid changes of cord compression. Measurements on antero-posterior x-ray films show that the interpedicular spaces of three or more vertebrae somewhere between the fourth and the tenth thoracic vertebrae are enlarged. The pedicles of the affected vertebrae especially those of the sixth, seventh and eighth, are narrowed and atrophic."* This clinical picture is an accurate portrayal of a patient suffering from an extradural cyst associated with a progressive kyphotic deformity of the thoracic spinal column. In addition to the neurological picture there must also be emphasized the associated vertebral deformity which is now recognized as part and parcel of the syndrome, and which is constant in all but one of the cases reported to date.

A good résumé of this condition has been recently made by Kelly, who reviewed eleven cases and added one operated upon by Jefferson. This case, typically, occurred in a boy aged fifteen, who showed progressive motor weakness of the lower extremities, moderate sensory impairment, and roentgenographic evidence of enlargement of the spinal canal, together with thinning of the pedicles. The extradural cyst was removed, and the boy made a complete recovery.

The location of these extradural cysts in the dorsal region is extremely constant, and the reason is rather difficult to explain in the light of the present known pathology of the condition. Additional patients have recently been operated upon by Teachenor, Mayfield and Spurling, Peet and Kahn, and Robertson and Graham. There have been several detailed theories attempting to explain the presence of the cyst either as a congenital diverticulum from the dura or as a herniation of the arachnoid through a defect in the dura. Since Mayfield and Spurling demonstrated the direct communication between the cysts and the subarachnoid space, the herniation theory has been favored by several observers. This, of course, can be entirely reconciled with the typical structure of these cysts, which contain fibrous tissue, such as is seen in the dura, and epithelial cells similar to those found in the arachnoid. The cyst wall in our case revealed no endothelial lining.

From the neurological examinations alone it is quite impossible to differentiate preoperatively this type of lesion from any other form of tumor causing spinal-cord compression. Gradually increasing paraplegia, with little or no pain, and severe impairment of position sense and deep sensibility make up the usual and typical picture seen when the patient is first examined.

The spinal-fluid examination usually indicates a fairly complete subarachnoid block. The total protein content of the fluid is generally increased, and the fluid itself is apt to be xanthrochromic in color, depending upon the completeness of the block. Where the possibility of a cerebrospinal block cannot be definitely established, the injection of lipiodol is indicated, although this has been found necessary in only five of the cases described.

The most interesting changes seen in this condition are those revealed by roentgenograms of the thoracic spinal column. There is a definite increase in the size of the spinal canal shown on the anteroposterior views. The so-called interpedicular spaces are definitely enlarged and striking measurements are quoted by Elsberg, Dyke, and Brewer, indicative of pathognomonic erosions at the level of the spinal cyst. The pedicles themselves may be reduced to mere shells or may be only flattened or reduced in thickness. Alterations in the vertebral bodies have been discovered in every instance. The earliest changes are in the nature of rounded erosions of the anterosuperior and antero-inferior surfaces. This erosive process continues, producing notching or stepladder defects in several vertebral bodies in the mid-thoracic region.

The involved bodies may finally collapse anteriorly, producing a wedging with the appearance of a smooth, rounded kyphos. The lesion in the bodies usually coincides with the level of the extradural cyst. As previously indicated, these vertebral changes are quite secondary to the spinal cysts due to the venous stasis, caused by compression of the channels draining these bodies. Theoretically, and practically, removal of the cyst should prevent a further breakdown and arrest of the process. This will have to be further observed before any final conclusions may be drawn, although from the cases reviewed to date the kyphotic deformity rapidly reaches a maximum degree following removal of the cyst, and no further breakdown of the vertebral bodies takes place.

An adolescent male or female with a rounded kyphos, presenting a progressive weakness of the lower extremities, together with changes in the vertebral bodies of the mid-thoracic spine as seen in kyphosis dorsalis juvenilis, delineates a fairly characteristic clinical picture indicating the presence of an extradural spinal cyst. The mild progressive sensory changes, the involvement of the sphincters, and finally the establishment of a cerebrospinal-fluid block, corroborate the diagnostic impression. The widening of the spinal canal, together with the increased measurements made visible by the erosion of the interpedicular spaces, is all the additional evidence necessary to warrant exploratory laminectomy.

SUMMARY AND CONCLUSIONS

1. A case of extradural spinal cyst associated with kyphosis dorsalis juvenilis is reported.
2. Sixteen other cases of spinal extradural cysts collected from the literature are presented.
3. The clinical picture of an adolescent with progressive paraplegia, together with erosion of the vertebral bodies in the mid-thoracic region as seen in kyphosis dorsalis juvenilis, is pathognomonic of an extradural spinal cyst.
4. All cases of kyphosis dorsalis juvenilis should be carefully examined for evidence of spinal-cord compression and for roentgenographic evidence of enlargement of the spinal canal.
5. The deformity seen in kyphosis dorsalis juvenilis with extradural cyst results from venous stasis secondary to the presence of the cyst.
6. The etiology of kyphosis dorsalis juvenilis unassociated with an extradural cyst is unknown.
7. Early surgical intervention with removal of the intraspinal cyst usually results in complete cure with relief of all signs of spinal-cord compression and prompt arrest of the kyphotic deformity.

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FRACTURES OF THE TIBIAL CONDYLES

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A large group of papers have been published in recent years in which fractures of the tibial condyles were reviewed in considerable detail. They have appeared in American, French, Latin-American, and German periodicals. All have given emphasis to the bad prognosis in such injuries, and to the frequent necessity for operative correction of irregularities in the articular surface caused by the depression or displacement of the condylar masses. Since, in general, the impression left by these papers was contrary to the experience of the writer, a further study of such cases was undertaken.

Between the years 1928 and 1939, 565 fractures of the tibia were admitted to the Mt. Sinai Hospital. Of these, sixty-one fractures in sixty patients, or 11 per cent., involved one or both condyles. Observations concerning the age, location, nature of trauma, and other clinical material do not differ in general from the standard descriptions, and so need not be repeated here. Of particular interest to the present investigation were, (1) the relationship between the type of the lesion and its prognosis, and (2) the effect of treatment on prognosis. In brief it was found that in a large series of cases representing all degrees of injury to the condylar mass, operative interference was very seldom indicated, and that conservative care plus time did not give the large percentage of bad results so often reported. Furthermore, it was found that remarkably good function could be recovered in the knee joint in spite of roentgenographic evidence of moderate compression of part of the articular surface.

For purposes of analysis the cases were divided into two major groups. Group I included those in which condylar fragments were not obviously displaced. Group II those in which condylar displacement was present. However, there is no sharp dividing line between the two groups. Some minimal displacement must occur whenever the joint surface is fractured. The distinction is one of degree rather than kind. Displacement of the fragment always occurs in at least two planes, horizontal and vertical, and may occur in three planes,—horizontal, vertical, and anteroposterior. When displacement in the vertical plane is most apparent, the term "depressed fracture of the condyle" is sometimes used, but since both elements are to some extent always present together, the term "displacement" is more general. Because of the special interest which pertains to the so-called depressed fractures, these are considered in a subgroup of Group II.

GROUP I

Simple or Comminuted Fractures without Displacement

This group consisted of twenty-two cases in which displacement could not be demonstrated by roentgenogram or was apparently minimal. Of these, five were comminuted, two were complicated by concurrent fracture of the head of the fibula, and one by fracture of the tibial spine. Treatment in the seventeen uncomplicated cases was chiefly by plaster immobilization for periods ranging from two to ten weeks. The time depended mostly on the linear extent of the fracture or the amount of joint injury, gauged by swelling, immobility, or tenderness. In most instances the plaster was applied from the groin to, and including, the toes, although in a few lesions of lesser severity, only from the groin to the ankle. The knee was held in extension or slight flexion (5 to 10 degrees). In one case adhesive strapping was sufficient for a small articular linear fracture; in another a simple bandage sufficed. Of the five cases in which comminution occurred, one was treated by traction and later by plaster immobilization. In another, plaster immobilization was maintained for ten weeks. The remainder were treated in the same way as were the simple fractures. Concurrent fracture of the head of the fibula or tibial spine did not noticeably influence the duration of treatment or the end result.

GROUP II

Fractures with Condylar Displacement

This group consisted of thirty-nine cases. In fifteen of these the vertical component of the displacement was prominent enough to be classified as a "depressed fracture". The treatment of these will be considered first. However, it must again be emphasized that in most, if not all, of the other cases of Group II some perceptible degree of depression of the condylar table occurred as a minor component of the displacement. In each of these fifteen cases some attempt was made to correct the deformity,—in the earlier cases under general anaesthesia, and in the later ones under local anaesthesia or by pressure on the setting plaster. In no instance of simple depression fracture in this series could evidence be found that any significant correction of surface irregularity had been obtained by manual reduction. In several instances, apparent improvement in the roentgenographic appearance was due to differences in the position of the extremity in reference to the film. Subsequent x-rays showed the original degree of depression. However, in two cases correction of the anterior angulation and posterior displacement was accomplished.

Thirty-one of the cases in Group II were treated, as were the cases in Group I, by means of plaster immobilization in extension or slight flexion. The most frequent duration of immobilization was between six and a half and seven and a half weeks, the time again varying with the linear extent of the fracture. The joint reaction had usually subsided before the plaster was removed. Although full weight-bearing was

Fig. 1

Case 8. Female, thirty-six years of age, was struck by an auto and suffered a depressed fracture of the right external condyle. She was immobilized in plaster and hospitalized for three days. Fourteen months later she had slight valgus, excellent function, and no disability.

Fig. 2

Case 10. Male, age forty-one, was struck by an auto and suffered a fracture of the left internal condyle with no displacement of the fragments. He was immobilized in plaster for six weeks and hospitalized for three months. Thirteen months later he had normal function and no deformity or disability.

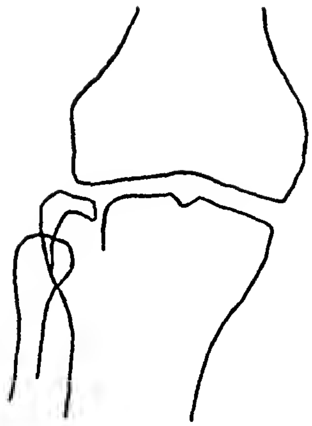

Fig. 3

Case 13. Female, age seventy-three, fell to the ground and suffered a depressed fracture of the right lateral condyle, and also fractures of the shaft of the tibia and fibula. She was hospitalized for ten days and treated by bed rest and caliper brace. Two years later she had slight lateral mobility, but no limp or symptoms.

prohibited, there was no hesitation in discharging these patients on crutches. *In no instance could evidence be found of an increase in bone deformity demonstrable by roentgenograms after the primary injury and displacement,* or during the follow-up, even though several patients bore weight on the immobilized extremity within two weeks. In nine of these cases there were concurrent fractures of the head of the fibula, but this fact had no perceptible influence on the duration of treatment.

In certain exceptional cases, treatment was modified to suit the circumstances. In one case, where the fracture involved both the internal and external condyles, and showed very marked displacement and comminution, treatment consisted of traction by Kirschner wire through the calcaneum for four weeks. At the end of this time the bones were sufficiently united and the wire removed. This patient's knee was still functioning normally without deformity seven years later. In another instance, a widely displaced fragment of an external condyle was removed. This knee was seen nine years later. At this time motion was free, but, although the patient walked well with slight valgus, he could not tolerate average periods of weight-bearing, and was discomforted by constant crepitus when using the limb. Lane screws were used in one case (Fig. 5) to hold the fragments in place after open reposition. In another (Fig. 4) wire traction, applied through the calcaneum, was supplemented by plaster immobilization. In view of the functional end results demonstrated

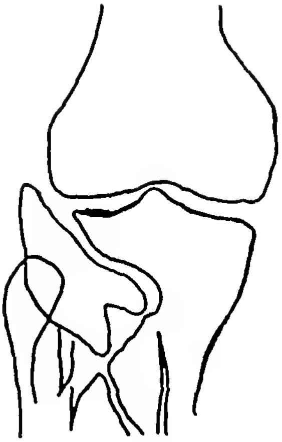

Fig. 4

Case 16. Female, age forty-one, had a fracture of the right external condyle. She was treated by wire traction and plaster immobilization, and hospitalized for a little over a month. The other knee had been fused for tuberculosis in childhood. Eight months later she had good function and no instability.

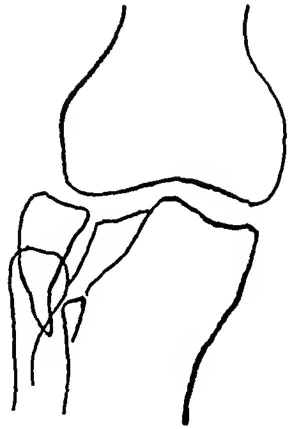

Fig 5

Case 23. Female, age forty-two, fell downstairs and suffered a fracture of the right external condyle, with separation of fragments. The fragments were held in place by a Lane screw and the knee was immobilized in plaster for ten weeks. Patient was hospitalized for five and one-half weeks. Almost eight months later she had restricted flexion and walked with a limp.

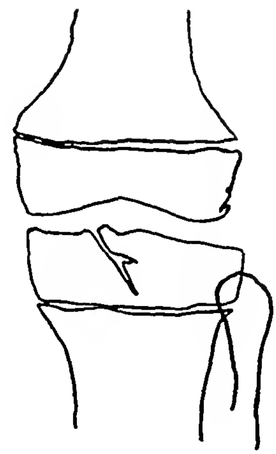

Fig. 6

Case 25. Male, twelve years of age, was struck by an auto and suffered a fracture of the left internal condyle with no displacement of fragments. He was immobilized in plaster for two weeks and hospitalized for one week. Eight months later he had normal function and no disability or symptoms.

in the present series, probably none of these cases would have been operated upon at the hospital today. In still another, a caliper brace was used for about six weeks, following nine weeks of plaster immobilization, in order "to prevent valgus". This was in 1935, but in retrospect this was an unnecessary precaution since the patient, followed for about a year, never became accustomed to the brace, and seldom walked with it. She walked easily when it was finally discarded. Lateral mobility, present in July 1936, had disappeared by October of that year.

HOSPITALIZATION

The duration of hospital stay in the treatment of fractures is impor-

TABLE I

Period of Hospitalization

Time	Group I	Group II
Accident room	9	9
2–7 days	4	7
8–14 days	3	6
15–21 days	0	3
3–5 weeks	2	2
Over 5 weeks	1	5
Total	19	32

FIG. 7

Case 32. Female, age seventy-two, was struck by an auto and suffered a depressed fracture of the left external condyle. She was immobilized in plaster, and after one week was transferred to another hospital. She also had arteriosclerosis.

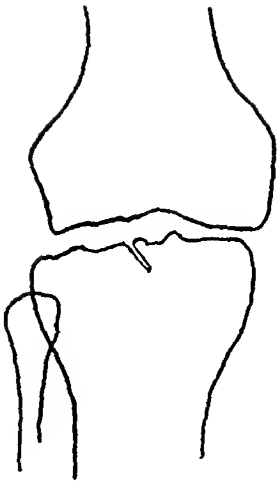

FIG. 8

Case 34. Female, age fifty-five, fell downstairs and suffered a depressed T fracture with slight deformity, of the right external condyle. She was treated in the accident room and referred to private care.

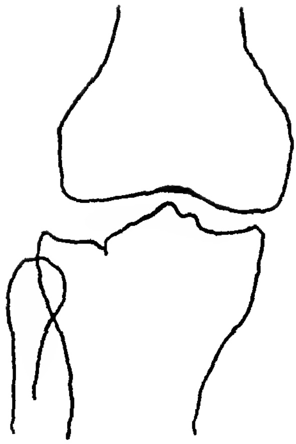

FIG. 9

Case 49. Female, age forty-nine, was struck by an auto and suffered fractures of the right external condyle and the left internal condyle. There was slight displacement in the right, and a linear fracture line without displacement in the left. The right knee (shown above) was treated by plaster immobilization and the left by adhesive strapping. She was hospitalized for two days. There was no follow-up.

tant from the point of view of both the patient and the hospital. General time averages reduced to a simple mean are inadequate to interpret such statistical material properly. Table I is a more accurate analysis. Nine cases in which there were complications incidental to the original accident, but not directly related to the fractured condyle, are not included as they would falsify the interpretation of the subject in question. For example, some of the cases of multiple fractures, those complicated by bronchopneumonia, fractures occurring in patients with known cardiac conditions, patients transferred to other hospitals and not followed, and one hospitalized for injury to the spine are omitted from the statistics.

The relative shortness of the hospital stay of cases admitted to the wards as compared to the hospitalization of operative cases is obvious.

END RESULTS

Complete follow-up data was available for the evaluation of end results in thirty-three of the sixty-one fractures. It may be added that in the remaining twenty-eight fractures, observations, as far as they went, tended to confirm the conclusions arrived at. The degree of functional recovery found in most instances, which showed roentgenographic evidence of residual irregularities, was surprisingly good. (See, for example, Figures 1 and 4.) Either because of contraction of opposing ligaments, or through replacement of the depressed bone surface within the

joint by fibrous tissue, the degree of valgus or instability suggested by the roentgenographic appearance was never clinically demonstrable.

The present series of unselected cases, which show all degrees of injury, demonstrate that while in about 10 per cent. of Group I and 20 per cent. of Group II, lateral instability of the knee joint was present in the early weeks following the removal of plaster, it almost invariably disappeared or decreased to a minimum between six and twelve months after fracture. This occurred with no after-treatment other than walking, and, in some instances, simple physiotherapy such as heat and massage. By the phrase "decreased to a minimum" is meant that no significant dysfunction or deformity was apparent while the patient was active. In other cases no significant lateral instability could be elicited at the knee joint at any time during the follow-up period. In only three cases was valgus or significant lateral instability noted as a deformity in the end result. One of these had been operated upon. In neither of the other two did the slight valgus interfere in any way with the function of the extremity.

One would suspect that in these fractures, occurring as they do for the most part in patients of middle age or older, traumatic arthritis would be a prominent disabling sequel. On the contrary, this appeared in only two cases. In one case, a female who sustained a fracture at the age of fifty-eight, showed evidence of generalized osteo-arthrosis five years later at the age of sixty-three. Both knees among other joints affected showed about equal involvement, and both were equally symptomatic. The fractured knee was normally mobile; there was no limp and no valgus deformity. In general, where symptoms of traumatic arthritis did not persist from the time of recovery, they did not appear in any of the fractures examined after periods ranging from two to nine years. Traumatic arthritis, when it occurred at all, manifested itself in the first year.

The only dysfunction which did remain in a number of cases was restriction of flexion to 80 or 90 degrees at the time of the last examination. This was rarely a noticeable disability in older persons, and usually tended to improve with time, if the patient was active.

Comminution or splintering of the adjacent shaft bore no apparent relation to the final outcome other than that of time,—the greater the extent of the fractured surface, the longer the period of recovery. In one case, in spite of severe comminution and displacement, and abnormal usage of the joint because of an old fusion of the opposite knee, due to tuberculosis, the functional result was good eight months later. Concurrent fracture of the head of the fibula which occurred in nine cases, did not, *per se*, adversely influence the course or end result. Fractures of the external condyle did not differ in their final status from those of the internal.

CONCLUSIONS

Sixty-one fractures of the tibial condyles have been reviewed with special reference to the end results in relation to type of fracture and treatment in thirty-three cases. The following conclusions were demonstrated:

1. Operative replacement of the depressed or fractured condyle is seldom necessary except in cases of extreme displacement, as satisfactory functional results are obtained even when considerable irregularity of the condylar tables persists.

2. Lateral instability of the knee joint is a temporary phenomenon in most of these cases, and decreases gradually during the recovery period. It cannot be considered permanent until the end of one year, and, *per se*, requires no treatment.

3. A slight valgus or varus deformity or even slight lateral instability is not incompatible with excellent function of the extremity, and the deformity does not progress.

4. Plaster or brace immobilization must be maintained until roentgenograms show evidence of satisfactory union. In most instances, six to seven weeks is sufficient. Prolonged immobilization detracts from the freedom of the joint and is unnecessary as a preventative of deformity.

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SOME ORTHOPAEDIC RELATIONSHIPS OF NEUROFIBROMATOSIS *

BY BEVERIDGE H. MOORE, M.D., CHICAGO, ILLINOIS

Dorland briefly defines a neurofibroma as "a connective tissue tumor of the nerve fibre fascicule, formed by proliferation of the perineurium and endoneurium", but this brief statement gives no hint of its numerous ramifications into many fields of medicine.

While neurofibromatosis itself shows only a few simple signs, its associations develop numerous complexities. They are frequently so striking that the primary condition is entirely overlooked. The common associations are:

1. Endocrine dyscrasias.
2. Mental changes.
3. Malignant transformations.
4. Skeletal changes (of interest to the orthopaedic surgeon).
   (a) Scoliosis.
   (b) Abnormalities of growth (usually hypertrophy).
   (c) Changes in bone structure.
   (d) Congenital pseudarthrosis in children.

This last relationship has only recently attracted attention, having been reported in 1937 by Ducroquet and in 1939 by Barber.

This paper is based on a study of four cases of localized hypertrophy, in all of which the diagnosis was confirmed by pathological study, and three cases of pseudarthrosis selected from a series of eight. These three were chosen because of familial evidence of neurofibromatosis, as well as the evidence in the cases themselves. In one of them the diagnosis was confirmed pathologically with interesting findings. The other five cases in our series all showed definite signs of neurofibromatosis.

LOCALIZED HYPERTROPHY

CASE 1. E. M., a Filipino engineering student, was admitted to Wesley Memorial Hospital, July 26, 1920.

He complained of difficulty in opening and closing his right hand. Flexion of the fingers caused a painful "snapping" located in the palmar region of the wrist. Extension repeated the process in reverse. Passive flexion and extension caused the "snapping" or "jumping", but this was not so painful. The condition had been present at intervals for several years. The second and third fingers were disproportionately large and had been so all his life as far as he knew.

The examination showed a palmar swelling from the mid-palmar region to a point one and one-half inches above the base of the palm. The swelling was soft, slightly tender, and somewhat fluctuant, but with no local heat. The second and third fingers were considerably longer and thicker than the normal, compared to the other fingers, and larger than the corresponding fingers on the left hand. The skin on these fingers was coarse in texture.

*Read at the Annual Meeting of the American Orthopaedic Association, Kansas City, Missouri, on May 8, 1940.

FIG. 1

Case 1. E. M. Postoperative photograph of the hand, showing the hypertrophy of the second and third fingers and swelling from the tumor at the base of the palm just above the line of incision. The change in the skin texture is seen down the middle of the palm.

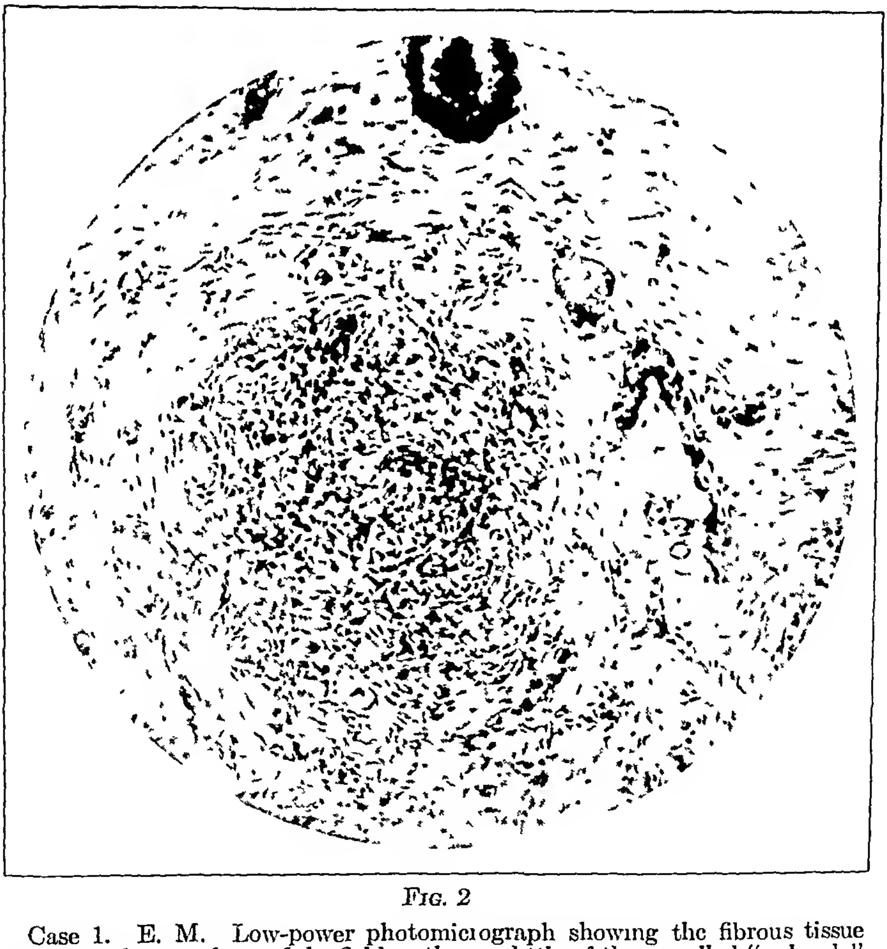

FIG. 2

Case 1. E. M. Low-power photomicrograph showing the fibrous tissue largely at the periphery of the field, with very little of the so-called "palisade" but some parallel arrangement of the elongated and narrowed nuclei, most noticeable in the upper left quadrant. The few vacuolations seen are presumably from degeneration of nerve fibers. This is an old mature type of tumor.

On attempted active flexion the fingers would stop at about midflexion, and, if the motion was continued, a distinct jumping could be seen and felt under the ligamentum carpi transversum. Pressure at this point prevented the motion and caused pain. A similar reaction took place on extension from the flexed position. These findings suggested a condition analogous to trigger finger,—that is, a thickening of the flexor tendons at the point where they passed under the transverse ligament.

On July 27, 1920, a three-inch longitudinal incision was made on the palmar surface of the wrist. Underneath the fascia a tumor was found, which extended from the middle of the palm into the wrist and was constricted by the transverse ligament into an hour-glass shape. This tumor was reddened, soft, and somewhat corded. At the proximal end it was continuous with the median nerve and appeared to be an expansion of it. It was realized at once that any attempt at removal might leave the hand worse; therefore, the transverse ligament was incised, and, after inspection of the flexor tendons which were normal, was sutured *under* the median nerve to relieve the pressure on the nerve. A small portion of the tumor was removed for microscopic study. The skin and fascia were closed *over* the nerve. Healing was prompt, and the motion of the fingers was normal afterward. For a while there was a small area of anaesthesia over the forefinger, but this eventually cleared up. The microscopic examination, reported by Dr. Zeit, showed a neurofibroma of the "*Ranken-neuroma*" type. The area of anaesthesia on the forefinger was interesting because that finger was not involved in the hypertrophic changes though its nerve fiber was involved in the fibromatous change. Evidently, also, in spite of the change, that fiber was still functioning so far as sensation was concerned.

FIG. 3

Case 2. M. P. Photograph taken on admission shows pigmented areas on the back, the left buttock, and the legs. On the large spot below the left scapula there is also a small hemangiomatous naevus. Another lies lateral to it also in an area of pigmentation.

The enlargement of the heel below the right internal malleolus was the site of the plexiform tumor which was easily palpable under the skin. There was a one-inch lengthening of the tibia. The calf was poorly developed.

CASE 2. M. P., aged twelve, was admitted to Shriners' Hospital, August 25, 1933, with the complaint of deformity of the right foot and leg. The child was said to be normal at birth, but deformity began at one or one and one-half years of age. The right leg was slightly bowed below the knee and the foot turned outward. The deformity had increased with growth, but did not cause marked disability. The right leg had been growing faster than the left; it was then one inch longer.

On examination it was found that the right foot was pronated, and that there was marked abduction of the forefoot at the mid-tarsal joint. The head of the astragalus was displaced inward almost directly below the internal malleolus. The heel projected backward more than normal and was rolled outward. The skin on the outer margin of the foot was loose, wrinkled, and thickened. In this same region and extending upward, there was a peculiar granular feeling to the subcutaneous tissue.

The muscles of the leg were all acting and of good power except possibly the posterior tibial. Sensation was normal in the skin of the foot. The right tibia was approximately one inch longer than the left. Brownish pigmented areas from one-quarter of an inch to two inches in size were scattered over the back and legs. In addition to the pigmented areas there were purplish naevi on the back, both of them in larger brown areas.

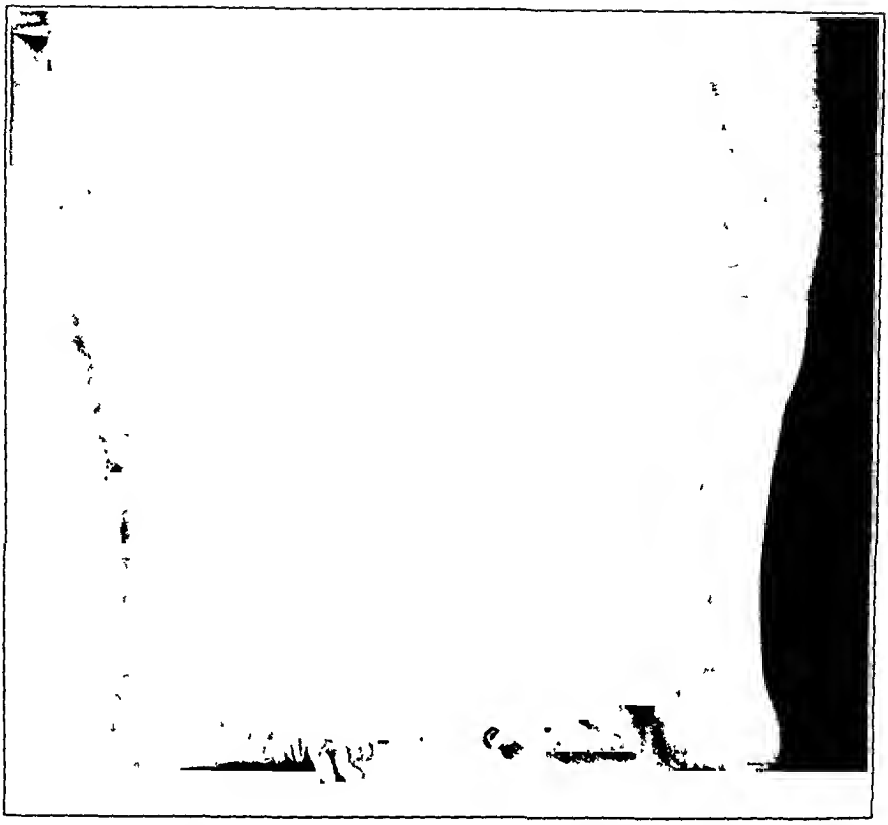

FIG. 4-A FIG. 4-B

Case 2. M. P. Photographs of the right leg show several typical pigmented areas, light ones just above the malleolus and about midway from the knee to the foot, and darker ones in the mid-calf region, and on the thigh.

There is marked lowering of the longitudinal arch with the prominence of the head of the astragalus easily seen. The foot is everted and the external malleolus has lost its normal prominence. The internal malleolus is masked by the fullness between the tibia and the tendo achillis which is the site of the tumor. The peculiar shape of the calf muscle is well shown.

The wrinkled loose skin near the heel extends from somewhat anterior to the malleolus to the outer side of the heel.

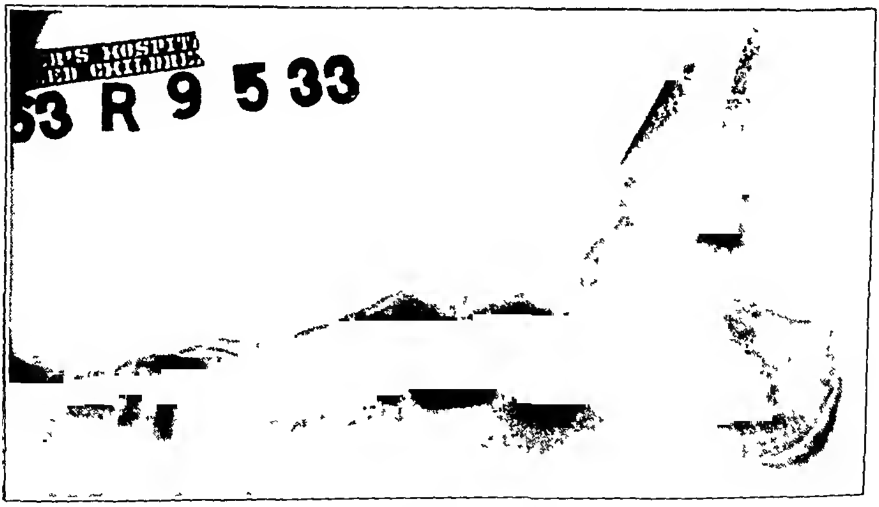

FIG. 5

Case 2. M. P. Roentgenogram shows the abnormal position of the astragalus with its axis almost straight with the tibia, its head rotated downward, and its posterior surface flattened, perhaps from weight-bearing in the faulty position. The lines of structure in the os calcis are altered. The entire longitudinal arch is lowered. The lower epiphyseal line of the tibia appears normal.

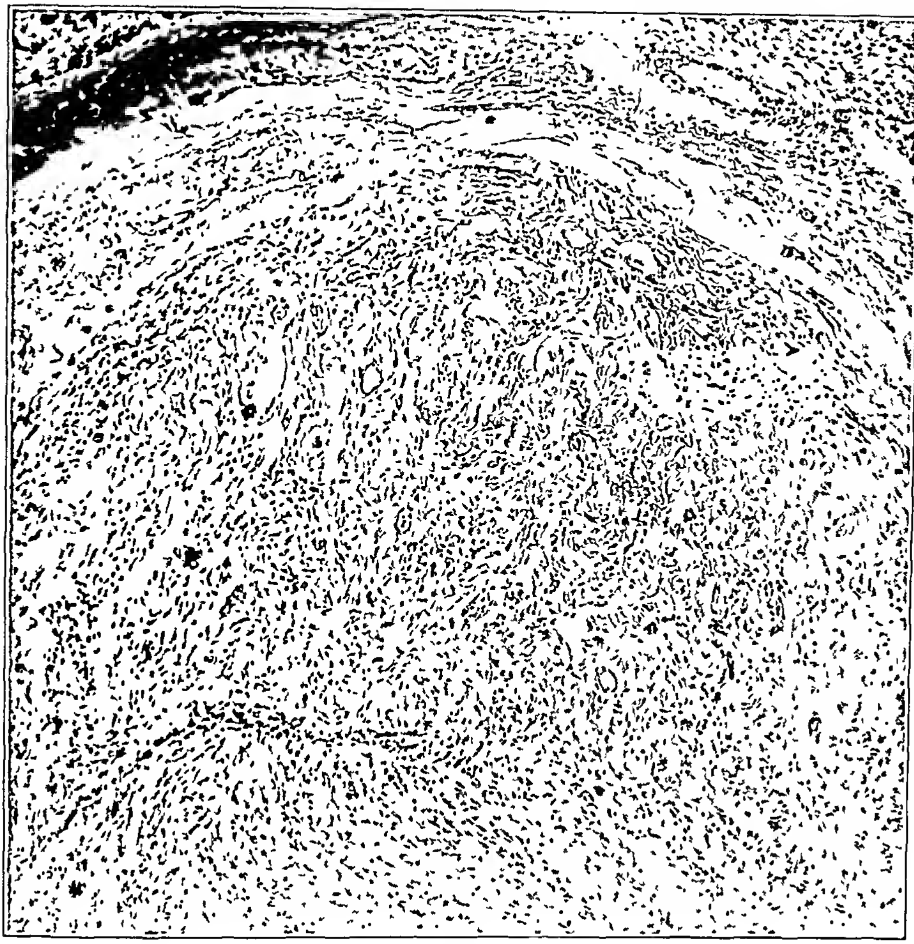

Fig. 6

Case 2. M. P. Low-power photomicrograph of about half a nerve fasciculus cut transversely shows the infiltration of fibrous tissue. There is very little "palisading" of nuclei though in the lower center area may be seen a small group. The nuclei are not markedly compressed. In the upper portion of the section a few fibrils appear to extend from the limiting membrane down into the fasciculus.

In the upper right hand corner is an arteriole whose walls are thickened and whose lumen shows a trace of a web. Possibly this is a beginning endarteritis. There are several areas of vacuolization.

The diagnosis was suspected neurofibroma or hemangioma.

A roentgenogram of the lateral view showed marked lowering of the longitudinal arch with displacement of the astragalar head; the anteroposterior view showed the scaphoid to be wedge-shaped and the foot markedly everted.

On September 7, 1933, an exploratory operation and biopsy was performed. A longitudinal incision, six inches long, extending upward from behind the internal malleolus, revealed a firm tortuous mass located in close proximity to the posterior tibial artery and vein but separate from them. It occupied the position of the posterior tibial nerve, but so far as it was dissected no normal nerve was seen entering the mass which could be palpated above the incision. The mass was covered by a definite sheath, and on opening this sheath the interior was found to consist of convoluted, hard, cordlike, solid, white fibers. From its character and position it was considered a neurofibroma and several small portions were removed for microscopic examination, but no attempt was made to remove the entire mass. Closure was made and healing was uneventful. The

Fig. 7

Case 2. M. P. High-power photomicrograph illustrating the arrangement of the nuclei in the connective-tissue background. In the upper half the parallel arrangement is predominant, while in the lower half the arrangement is more in whorl formation. Slightly to the right of center the nuclei are definitely "palisaded". In the lower left-hand corner is a similar area, but the nuclei have been sectioned transversely.

pathological report was neurofibroma. Following this operation the skin was checked carefully for changes in sensation but none were found. Apparently the nerve was still functioning, but the portions removed were not large and the normal overlap may have taken care of the areas removed for examination.

Case 3. D. D., aged eleven, was admitted to Shriners' Hospital, March 3, 1934, complaining of deformity of the right foot and leg.

The mother had noticed some deformity of the foot soon after birth, but it was not extreme, and she had not paid much attention to it. When the boy was about three years old, she noticed the right leg was growing faster than the left, and the deformity of the foot was increasing. The leg continued to outgrow the other and the limp became worse.

On examination the right foot was found badly everted and the longitudinal arch nonexistent. The astragalus seemed to be in normal relationship to both the tibia and scaphoid. The tarsal joints of the foot were very mobile and gave the impression that the ligaments were lax. This condition was especially noticeable in the subastragaloid and mid-tarsal joints. On the outer side of the foot the skin was loose and wrinkled, its

texture coarse and the lines deepened, a condition which extended almost to the toe. Back of the external malleolus there could be felt a tortuous, corded, plexiform tumor extending upward between the tendo achillis and the fibula. The right tibia was about two inches longer than the left. The calf muscle was not well developed. All the muscles had good power though it was difficult for them to exert it to the full because of the looseness of the tarsal joints. Skin sensation was normal. There were numerous areas of brown pigmentation on the legs, trunk, arms, and neck.

A roentgenogram showed a marked lowering of the longitudinal arch. The os calcis and the head of the astragalus were small and misshapen.

On March 15, 1934, the tumor was exposed through an incision back of the fibula.

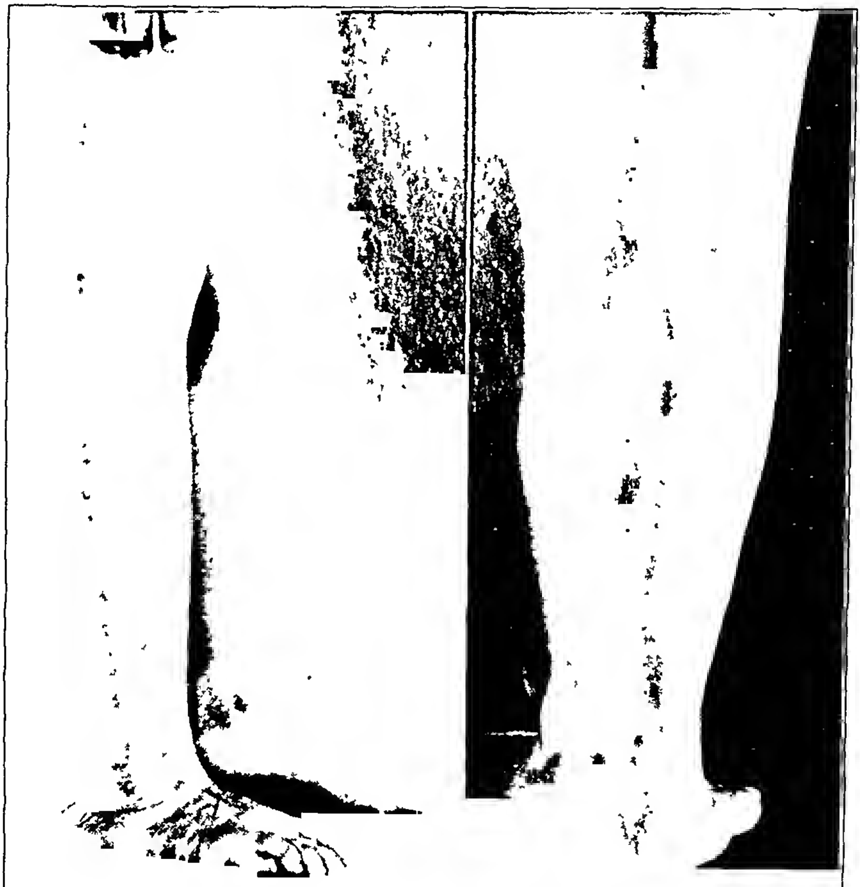

Fig. 8-A Fig. 8-B

Case 3. D. D. Photographs show the eversion and abduction of the right foot and the increase in length of the right leg. The deformity shown in this foot was due to the very marked laxity of the tarsal joints, but was not a fixed deformity as shown in Case 2.

Across the heel and along the outer margin of the foot there is a sharply outlined area of change in the skin texture. The skin in this area was thickened, wrinkled, and loose, and the texture much coarser than in other areas.

Several areas of pigmentation are visible, one near the location of the head of the fibula, and three just above the level of the patella.

On the dorsal surface of the foot can be seen two flattish soft tumors. They are not the usual pedunculated variety seen in adults, but may be an early stage of these tumors. The area in which the plexiform tumor was found is shown by the fullness external to the tendo achillis. The fullness internal to the tendon was apparently due to the laxity of the tarsal joints which allowed the ankle to sag inward.

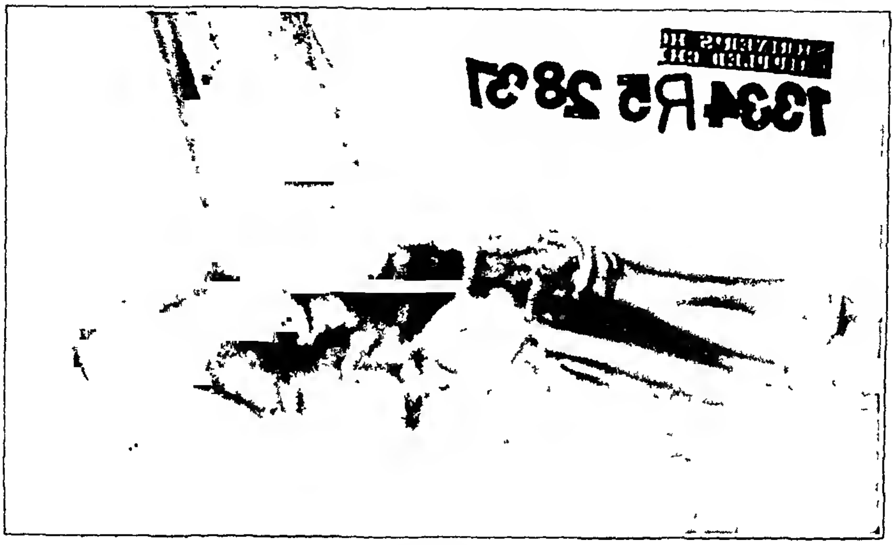

Fig. 9

Case 3. D. D. Roentgenogram of the lateral view of the right foot shows all of the tarsal bones to be misshapen and smaller than normal, whereas the tibia was two inches longer. This condition of the bones probably accounts for the laxity of the tarsal joints. There is a distinct mottling of the metatarsals and the row of tarsal bones adjoining them. The medullary canals of the metatarsals, with the exception of the first metatarsal, are distorted and irregular. The bones appear irregularly developed, rather than atrophic.

The epiphyseal line of the tibia is not distinct and is narrower than usual at his age. The longitudinal trabeculation of the tibia is much more pronounced than the transverse, which is characteristic of rapid bone growth. There are no lines of arrested growth.

This roentgenogram shows evidence of a distinct mixture of over and under development in the same member.

It presented a maze of cordlike convoluted fibers. A large portion of the structure was dissected out and removed. An arthrodesis between the head of the astragalus and the scaphoid was also done. Healing was uneventful.

The pathological examination showed a neurofibroma of a mature type. There was also a definite endarteritis present, shown not only as a thickening of the walls, but as a definite fibrous web extending across the lumen of several vessels. This was the first case in which the condition was found so definitely, and it may be of considerable importance.

At the time of discharge from the Hospital the skin of the foot and leg was carefully checked for sensory changes, but none was found. This is rather curious as a large amount of the neurofibromatous tissue was removed, and it seems as though there should have been some sensory change if the nerve were functioning. At his last visit three years later the discrepancy in the leg length was three inches, an increase of one inch.

Case 4. L. McC., aged thirteen, was admitted to Shriners' Hospital, August 17, 1935, complaining of difficulty in walking on account of a deformity of the left leg and foot. The deformity consisted of a marked overgrowth of the lower leg, and distortion and extreme flaccidity of the foot. The father said that the foot was "turned outward" when the boy was born, but that the legs were of equal length. The patient began walking at two years of age, with the weight borne on the *inner* side of the foot. At that time there was an enlargement developing in the calf and around the heel which continued to increase. A few months later it was noticed that the left leg was growing faster than the right. This it has continued to do. About four years ago he developed a slight curvature of the spine which has increased rapidly.

On examination the foot was found to be dorsiflexed and rotated outward, with the heel drawn forward directly under the tibia. All the joints of the foot were extremely

lax so that the sensation was of the bones being loose in a bag of skin. The calcaneum and the tarsal bones all felt much smaller than normal. The skin of the foot posterior to the metatarsal region was loose, deeply wrinkled, and of coarse texture. Underneath the skin could be felt a mass of cordlike bands and nodules. The sensation was strikingly like a bag of angleworms. This condition extended two-thirds of the distance to the knee dorsally. The *left* tibia was approximately six inches longer than the right. Skin sensation was normal and the muscles were all acting, but weak.

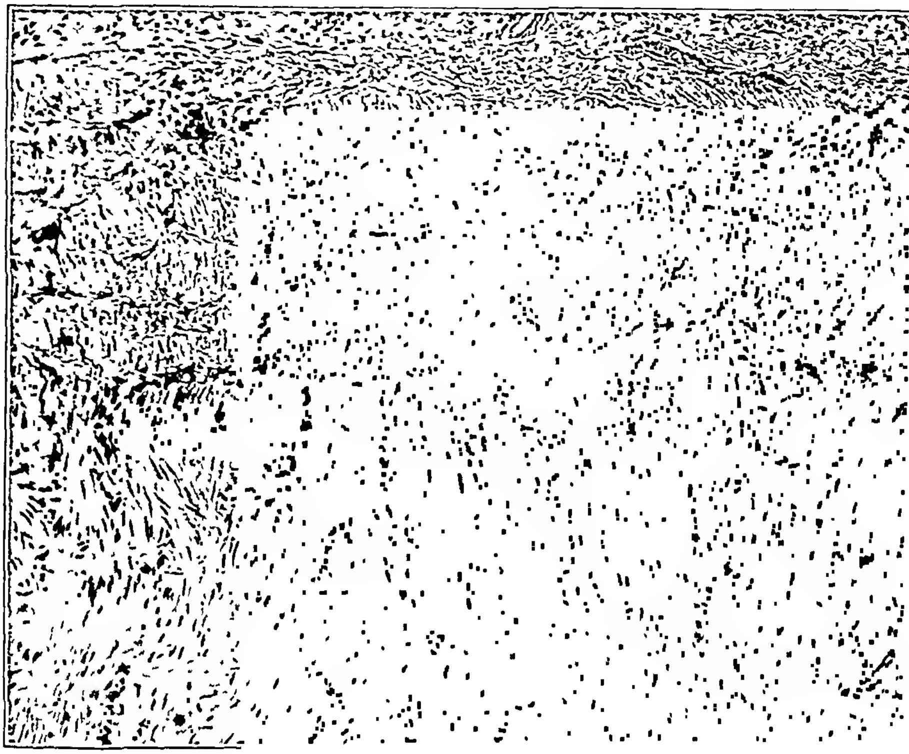

FIG. 10

Case 3. D. D. Low-power photomicrograph of section shows almost pure fibroma with very little evidence of nerve tissue. At the bottom there is what might be called a "streamline" arrangement while on the top the tissue is more irregularly arranged, but has a tendency toward whorl formation. The nuclei are elongated; there is some "palisading"; and a very distinct parallel arrangement. There is some vacuolization.

FIG. 11

Case 3. D. D. High-power photomicrograph illustrates an advanced fibrous replacement of the peroneal nerve. Note the parallel arrangement of the compressed and elongated fibroblasts. In the area near the center there is a distinct reticular appearance of the fibrous tissue.

FIG. 12

Case 3. D. D. High-power photomicrograph shows much more of the whorl arrangement than the streamline or parallel. There are several areas of vacuolization. However, the point of special interest is the two blood vessels near the center. In both the wall is much thickened. In the vessel on the right there is a distinct web of fibrous tissue extending across the lumen. The lumen itself is flattened from side to side as if the fibrous web is drawing the sides together. In the vessel on the left the web is more extensive, hiding more than half the lumen which is also narrowed from side to side. This is a definite endarteritis,—a condition which we have not found mentioned, but which may be of importance in accounting for certain findings in neurofibromatosis.

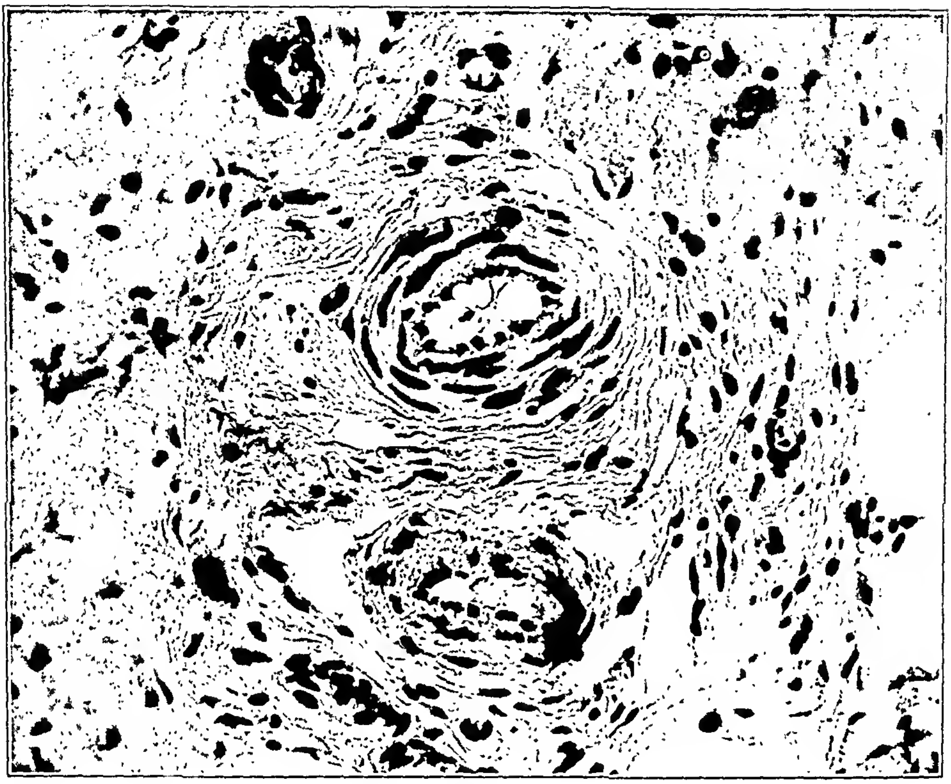

Fig. 12
(See page 117)

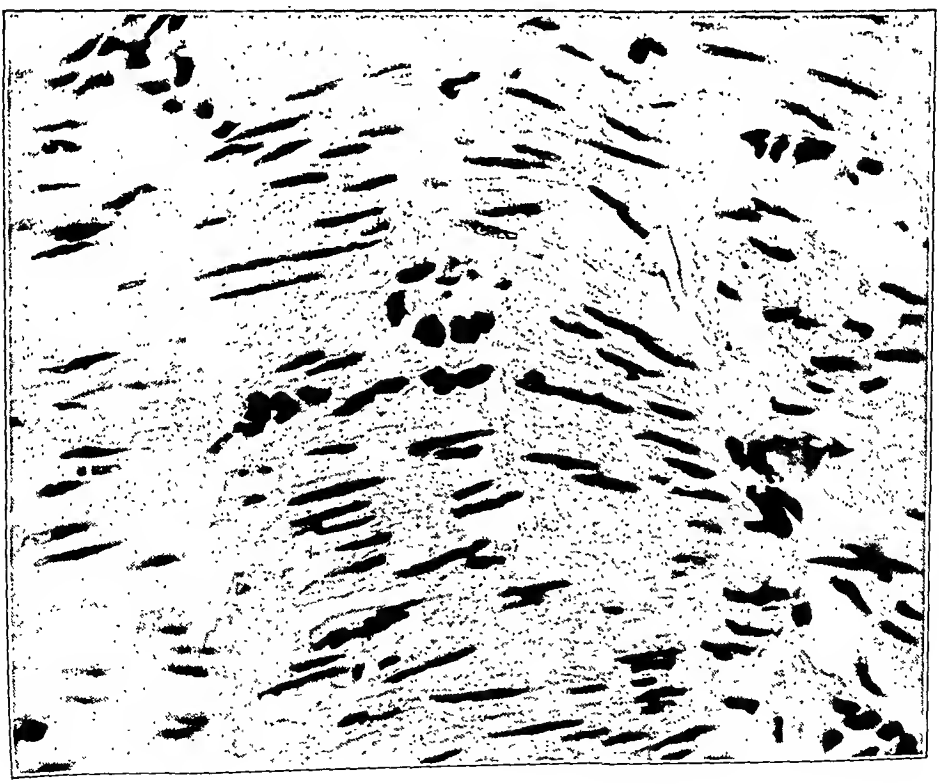

Fig. 11
(See page 117)

Fig. 13-A

Case 4. L. McC. Photograph of side view shows marked overgrowth of left lower leg with deformity and skin changes of the foot. Note also kyphoscoliosis. Pigmentary changes were present but not prominent in this case.

Fig. 13-B

Photograph of the front view shows the extreme overgrowth of the left leg below the knee. The tibia was six inches longer than on the right side. The elephantiasis was marked throughout the leg and the loose baggy condition about the heel is well shown.

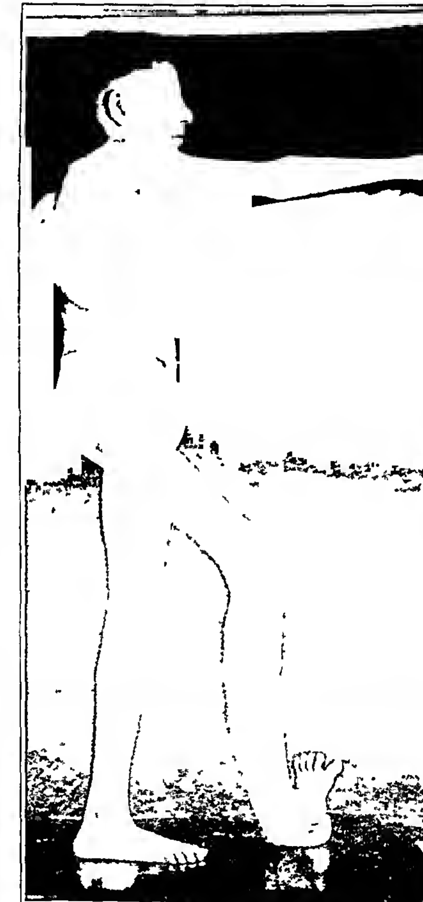

Fig. 13-C

The kyphotic element of the spine deformity is well shown in this lateral view, also the extreme distortion of the foot and leg are obvious.

There is a definite pigmented area over the right scapula and another small one behind the trochanter. The condition of the skin over the tip of the nose can be best seen in this view.

FIG. 14

Case 4. L. McC. Roentgenogram of lateral view of the left foot. The distortion, underdevelopment, and displacement of all the tarsal bones, including the astragalus and os calcis, is most noticeable. The metatarsals and phalanges appear fairly normal in shape, but atrophied probably from lack of function. The os calcis and astragalus appear fairly hard even though misshapen.

The tibia is rather narrow and lacks the usual flare at the lower end. The cortex is thin but not excessively so. The epiphyseal line is narrower than normal and not distinct. There is little bone marking in the lower end, and the transverse lines of cessation of growth are absent unless there is a rudimentary one about an inch above the lower end.

The spine showed a marked scoliosis to the right in the dorsal region with its apex at about the sixth dorsal vertebra. The apex was sharp with a marked kyphotic element. There was some compensatory curve in the lumbar region though not so much as is usual with so marked a dorsal curve.

There were numerous brownish pigmented areas over the body. The skin of the face was somewhat red, suggesting a slight hemangiomatous birthmark.

Roentgenographic examination showed marked distortion of practically all the bones of the foot except the metatarsals and phalanges. The tarsal bones were widely separated. All of them were notably small and ill shapen. The tibia was narrower than usual and lacked the usual flare near the ankle. The epiphyseal line was present and appeared about normal. Roentgenograms of the spine showed several misshapen vertebrae at the apex of the dorsal angulation. The upper and lower vertebral epiphyses were present on one side of the vertebral bodies but missing on the narrower side. There were no fused ribs.

On August 27, 1935, a biopsy was done in two regions. The tissue removed was reported as neurofibroma. On September 26, 1935, the leg was amputated about five inches below the knee. Healing was prompt and the patient was eventually fitted with an artificial leg.

In this case the microscopic section showed a typical neurofibroma with the fibrous tissue greatly predominating. In addition there was definite evidence of endarteritis with marked web formation in one section.

Description of the Amputated Specimen

The amputated portion consisted of approximately the lower two thirds of the leg below the knee and was twenty inches long from the upper end of the amputated tibia to the tip of the great toe. The upper end of the tibia was elliptical in shape rather than triangular which is usual. The cortical bone, approximately one-sixteenth of an inch thick, was thinner than normal. The sectional muscle was much smaller in area and markedly paler than the normal muscle. The subcutaneous fat was increased in amount and presented a somewhat lobulated appearance. The skin was somewhat thicker than usual. In section the tibial nerve was noticeably enlarged, being slightly over one-half inch in diameter. The skin covering the amputated specimen showed a coarse texture,

particularly over the calf and the sole of the foot, but was less so on the anterior surface of the leg and the dorsum of the foot. This changed texture was most marked in the lower portion of the leg and below the malleoli, where it was loose, and arranged in irregular folds. The creases between the folds were from one-quarter to one-half inch in depth. Within this loose, baggy skin, which was quite moveable on the tissues beneath, the bones could be felt smaller and much more mobile than normal. The specimen was placed in formalin and dissected later. The formalin, of course, destroyed much of the hypermobility of the skin and the joints. At the time of dissection the tibial nerve was removed for examination. The portion removed was seventeen and one-half inches long, and markedly enlarged. A number of nodules which were fusiform enlargements of various fasciculi within the nerve, could be felt throughout its course, but none of them were separate from the nerve, which continued on beyond the enlargement. The subcutaneous region in the lower portion of the specimen was tough and fibrous, and gave the impression of being oedematous, though of the brawny type. The ligaments were lax and poorly developed, but not grossly abnormal. The bones of the foot were very small and extremely misshapen, corresponding to their roentgenographic appearance. They were so very soft that they could be compressed between the thumb and finger. The cortex was thin and easily cut with a knife. Within there was very little of the usual cancellous structure, but there were frequent cystic areas which did not have bony walls nor any apparent reaction in the bone surrounding them, and were filled with a thin fatty material. They seemed to be areas of exaggerated bone atrophy rather than a reaction to irritation.

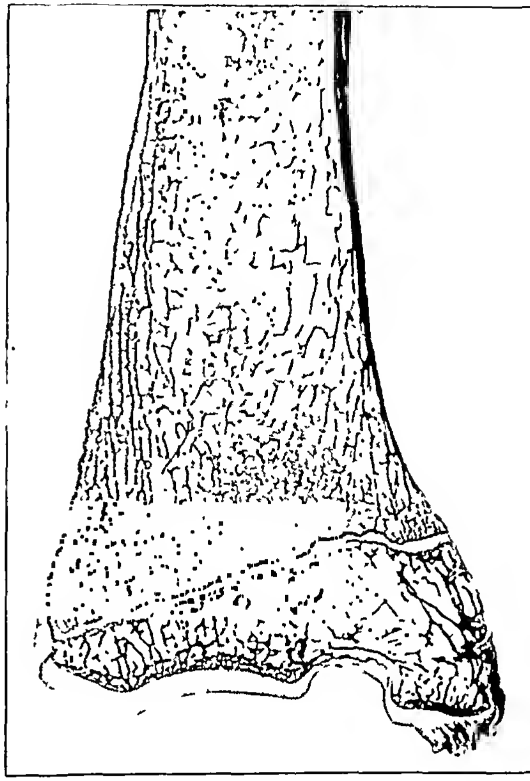

FIG. 15

Case 4. L. McC. Very low-power photomicrograph of section of the lower tibia. Note the preponderance of longitudinal trabeculae except immediately above the epiphyseal line. There was very little evidence of either osteoblastic or osteoclastic activity in the section. The epiphyseal line is narrowed and irregular in outline just above the defect in the articular surface. Note also the irregularity of ossification of the epiphysis between these two points.

The last report in this case was from his teacher who stated that his mental condition, which was "queer" in the Hospital, was rapidly becoming worse, and that he was unable to remain with normal children in school.

COMMENT ON HYPERTROPHY CASES

These four proven cases of neurofibromatosis all present one common feature—localized hypertrophy—in addition to the cardinal signs of skin pigmentation and plexiform tumor. Cases 2, 3, and 4 form a progression in the degree of deformity, which began before three years of age,—normally a period of rapid growth. Enough cases of localized hyper-

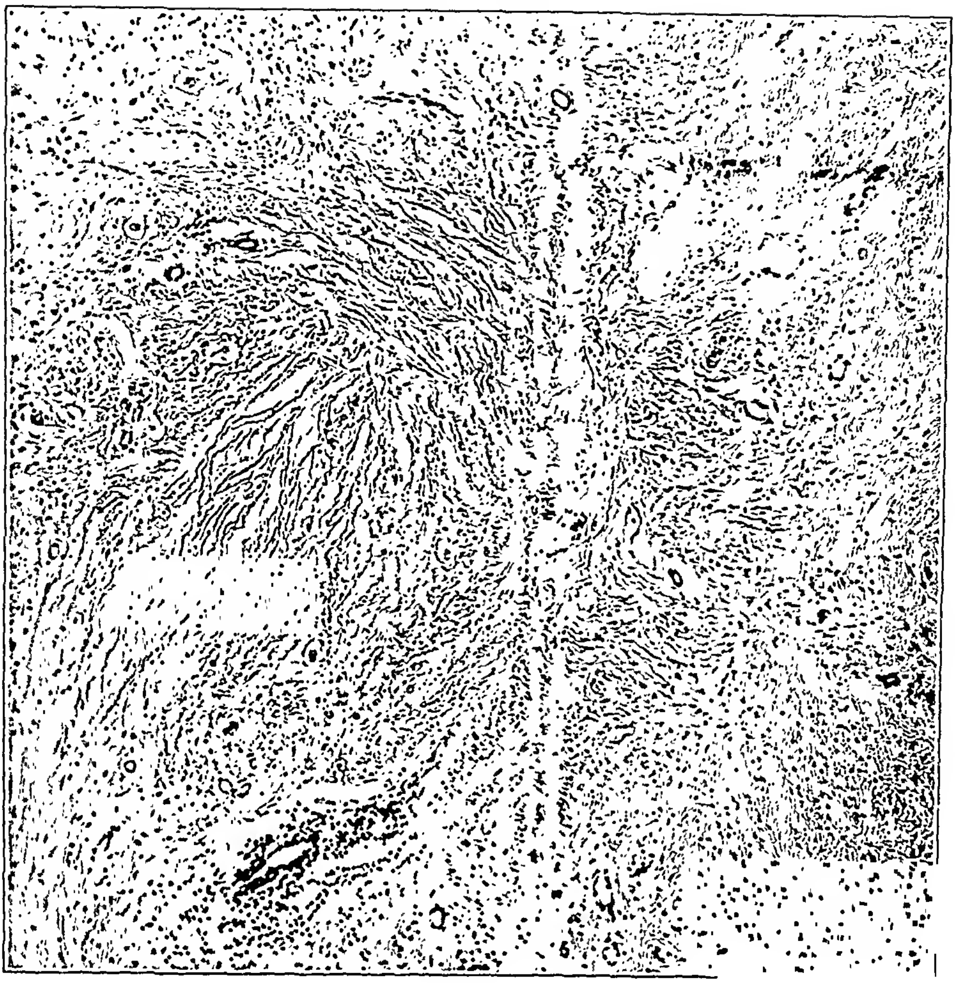

FIG. 16

Case 4. L. McC. *Low-power photomicrograph of section from plexiform tumor of posterior tibial nerve showing tangled mass of fibrous tissue of mature type. In this case there is very little orderly arrangement of the fibroblasts though in certain areas there is some tendency to parallelism. Note the thickness of the walls of the arteries.*

trophy associated with neurofibromatosis have been reported to make it seem more than a coincidence. However, the strongest point in favor of the theory that the neurofibroma is the cause of the overgrowth is the fact that there is a definite segmental relationship between the affected nerve and the overgrowth. Brooks and Lehman go so far as to say that there is no other cause for rapid localized overgrowth than neurofibromatosis. They ascribe the overgrowth to stimulation by actual invasion of the bone by neurofibroma. To quote them briefly, "If the tumor . . . involves the substance of the shaft of the bone and particularly if the growth of the neurofibroma is associated with a hyperplastic change in the lymphatics, then the entire bone is rendered more porous and plastic . . . this results in a growth in length of the bone, which is distributed throughout the entire bone instead of being confined to the region of the epiphyseal cartilages, and an abnormally long bone results." We find it difficult to

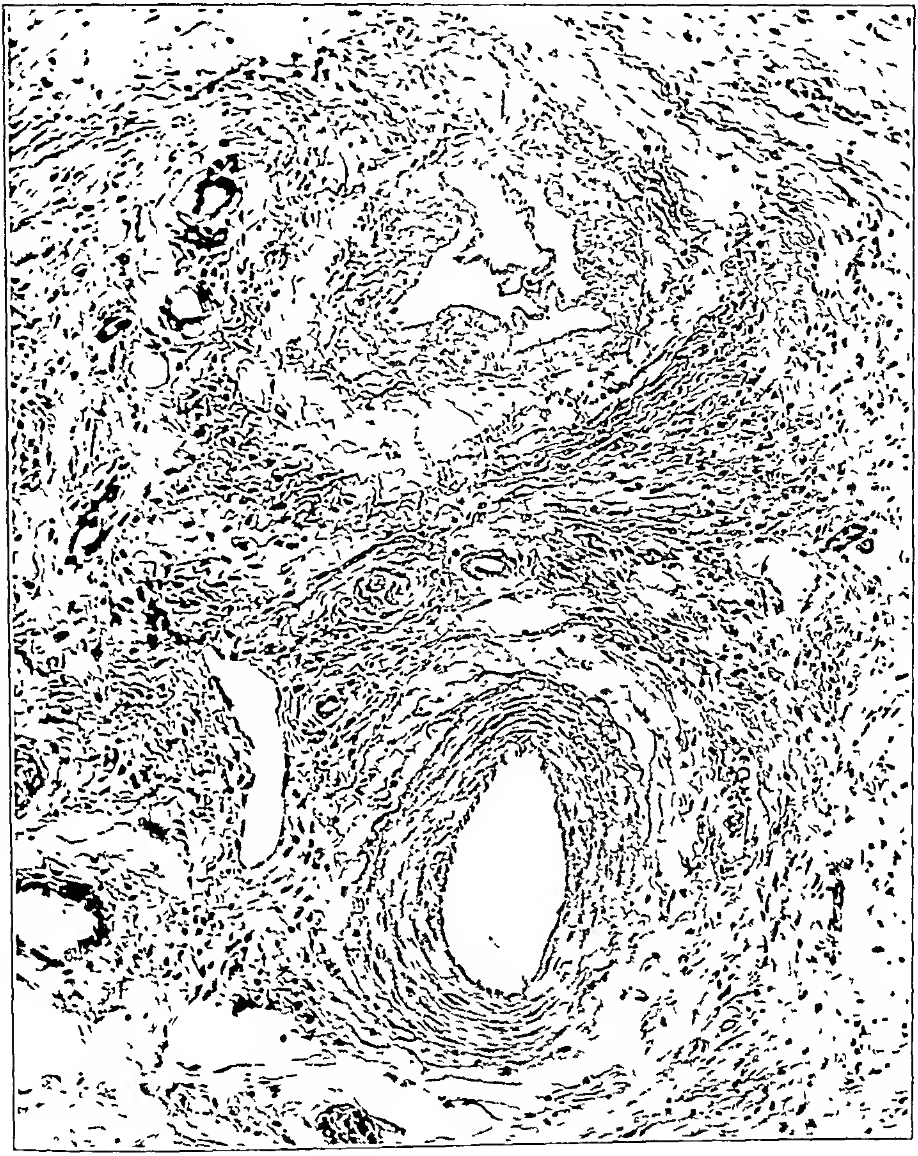

FIG. 17

Case 4. L. McC. High-power photomicrograph of two small arteries within the fibrous tissue. Note the thickened walls of both. In the lumen of the one at the top is seen a weblike endothelial hyperplasia. The lumen is irregular in shape. This is a definite endarteritis.

accept the theory that the bone grows throughout its length since it runs so directly counter to all recent work on the growth of bone. Furthermore we can find no report of actual invasion of the shaft by the neurofibroma. The tibia in Case 4 was sectioned with this very point in mind and no evidence of it could be found.

There is also a school of thought which ascribes the overgrowth to endocrinological changes. Granting that the anterior pituitary does control bone growth, it is difficult to see how a hormone which by its very

nature must have equal access to all parts of the body can cause the sharply localized overgrowth we have noted. We believe that overgrowth takes place at the epiphyseal line as in normal bone, but at a greatly accelerated rate.

Harris in his study of bone growth states that in rapidly growing bone the longitudinal trabeculae are laid down before the transverse. In the roentgenogram of the tibia in Case 4 this condition is quite distinct. It is also shown in a longitudinal section cut from the lower end of the tibia. There is, too, a notable absence of the lines of cessation of growth as described by the same author. The same condition is shown in the roentgenograms of the other two cases, but to a lesser degree. This we believe to be evidence of abnormally rapid growth from the ends of the bone. It would be easy and obvious to assume a stimulation of growth activity, but another fact must be taken into consideration. We pointed out that the tarsal bones in all three of these cases were small and misshapen in varying degrees, that is, there was in these cases not pure overgrowth, but a mixture of over and under-development. The scoliosis in Case 4 seems to show the same condition, since on the wider side of the vertebral body the epiphyses are present, while on the narrower side they are not seen. We believe this is an evidence of growth distortion rather than a crushing of the vertebral body from softening. We believe that these findings (mixed over and under development) indicate, not stimulation, but rather faulty control of growth.

Fig. 18

Case 5. D. G. August 30, 1929. Photograph on admission shows the anterior bowing of the right lower leg, distinct pigmented areas over the lower spine, one faint area between the inferior angle of the right scapula and the spine, and two faint areas above the right external malleolus.

In the growth of the bones there are two factors,—one the impulse to grow, and the other the limitation and direction of the growth so that a normal pattern is attained. Does the nervous system exert this control? Certainly in these cases there is a defective pattern of growth associated with a defective nerve. The arterial changes may be of significance in this connection. Possibly the autonomic nervous system, which controls the arteries, may also have some control over growth. It may be a collaborator with the endocrine system in this.

The facts as we see them are these:

1. Localized hypertrophy is often enough associated with neurofibromatosis in a segmental relationship to warrant a belief that there is a causal relationship of the nerve lesion to the hypertrophy.

2. The hypertrophy is not pure overgrowth, but is mixed over and underdevelopment, and we believe represents uncontrolled growth rather than stimulation of growth.

3. The findings of definite evidence of endarteritis in two of these

FIG. 19-A

Case 5. D. G. Roentgenogram taken April 2, 1930, shows fracture of the right clavicle. This was a complete fracture, not a "greenstick".

FIG. 19-B

Roentgenogram taken April 29, 1930. The callus had formed well and union was firm in three weeks. The tibia was still ununited.

FIG. 20-A FIG. 20-B

Case 5. D. G. Roentgenograms taken June 1, 1932, almost three years after operation, show lateral and anteroposterior views of right leg. Union in malposition has finally taken place. The fibula has atrophied and there is no attempt at union. The union of the tibia does not appear any too solid as the medullary cavity of the lower fragment has narrowed and sealed over. The medullary canal of the upper fragment is open, but not in contact with the lower fragment. Near the upper and lower ends of the diaphysis are seen several transverse dark lines described by Harris as caused by temporary cessation of growth. We have considered that they may be due to cod-liver-oil administration at intervals.

Note especially the heavier dark line across the tibia above these finer lines. It is heavier and in the lateral view is triangular in outline. The posterior cortex shows a slight angulation at its base.

cases, and hints of it in the other two, may, we believe, have a bearing on the question of the control of normal bone growth.

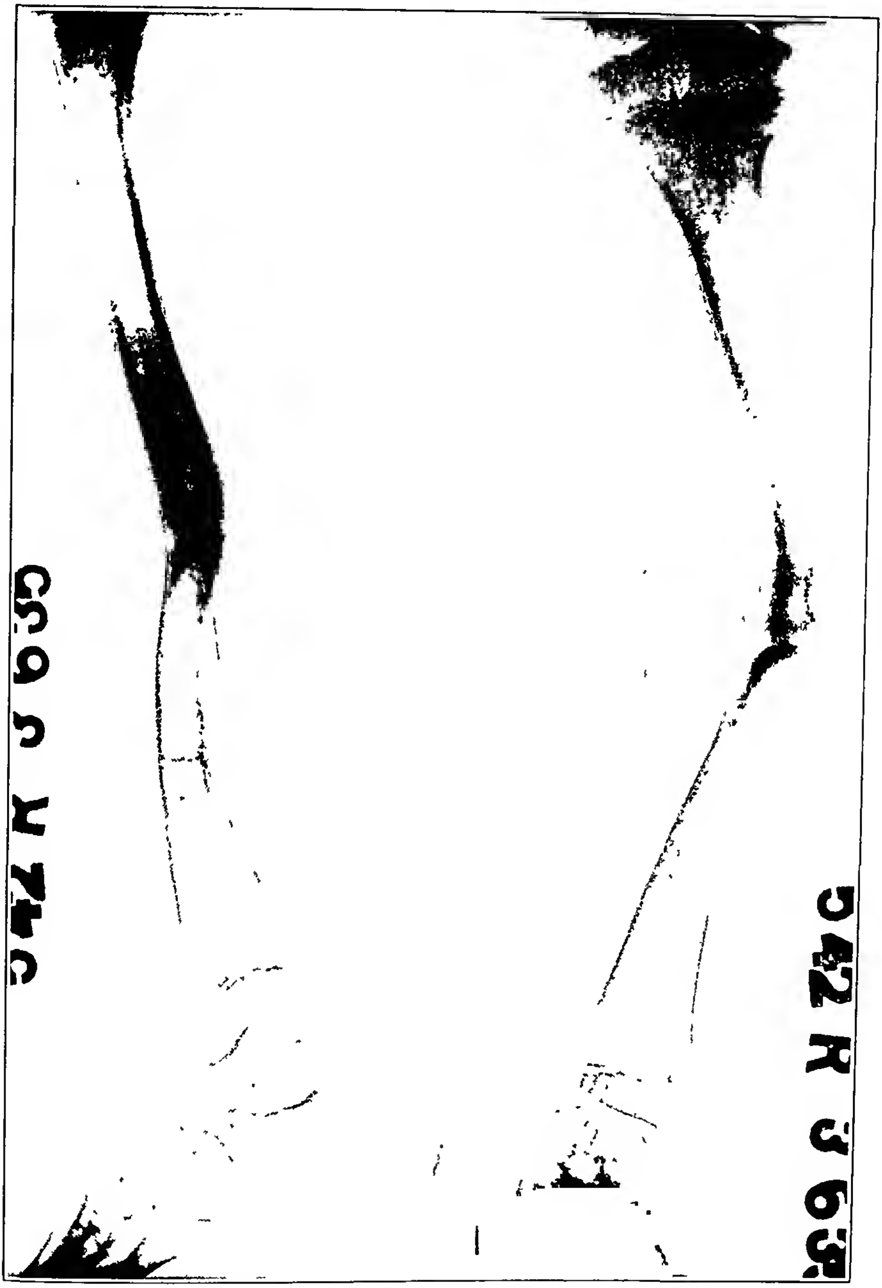

Fig. 21-A Fig. 21-B

Case 5. D. G. Roentgenograms of lateral and anteroposterior views taken March 6, 1935. Union is present though the fracture had recurred in 1933. The angulation has rounded off and the medullary canal is showing signs of opening up through the callus. There are a few lines of cessation of growth near the lower end of the diaphysis. The heavier dark line to which attention was called in Figures 20-A and 20-B is still present, though at a relatively higher level. The epiphyseal line has advanced away from it, leaving it higher in the shaft. The slight angulation in the posterior cortex is still present.

PSEUDARTHROSIS

CASE 5. D. G. was first seen at Shriners' Hospital, March 9, 1929, when she was fourteen months old.

The complaint was that her right leg was bowed.

She was born normally at full term, breast fed for nine weeks, and then put on a

FIG. 22-A FIG. 22-B

Case 5. D. G. Roentgenograms of lateral and anteroposterior views taken January 15, 1936. The medullary canal has finally formed somewhat irregularly through the callus. There is a fresh fracture at the junction of the lower and middle thirds of the tibia at the site of the dark line to which attention was called in the two previous plates. This was apparently a danger signal a little over two years before the actual break.

formula. She had cod-liver oil and orange juice regularly. At ten months she began to pull herself up and walk, holding the sides of the crib, but stopped this shortly because she hurt her leg. She soon began to creep and kept this up until she was twelve months old, when she resumed walking. Her mother then noticed that her right leg began to curve above the ankle. Pigmentation was not noted on the first visit. Later when it was observed, her mother stated that she and the father did not have it, but an aunt did have

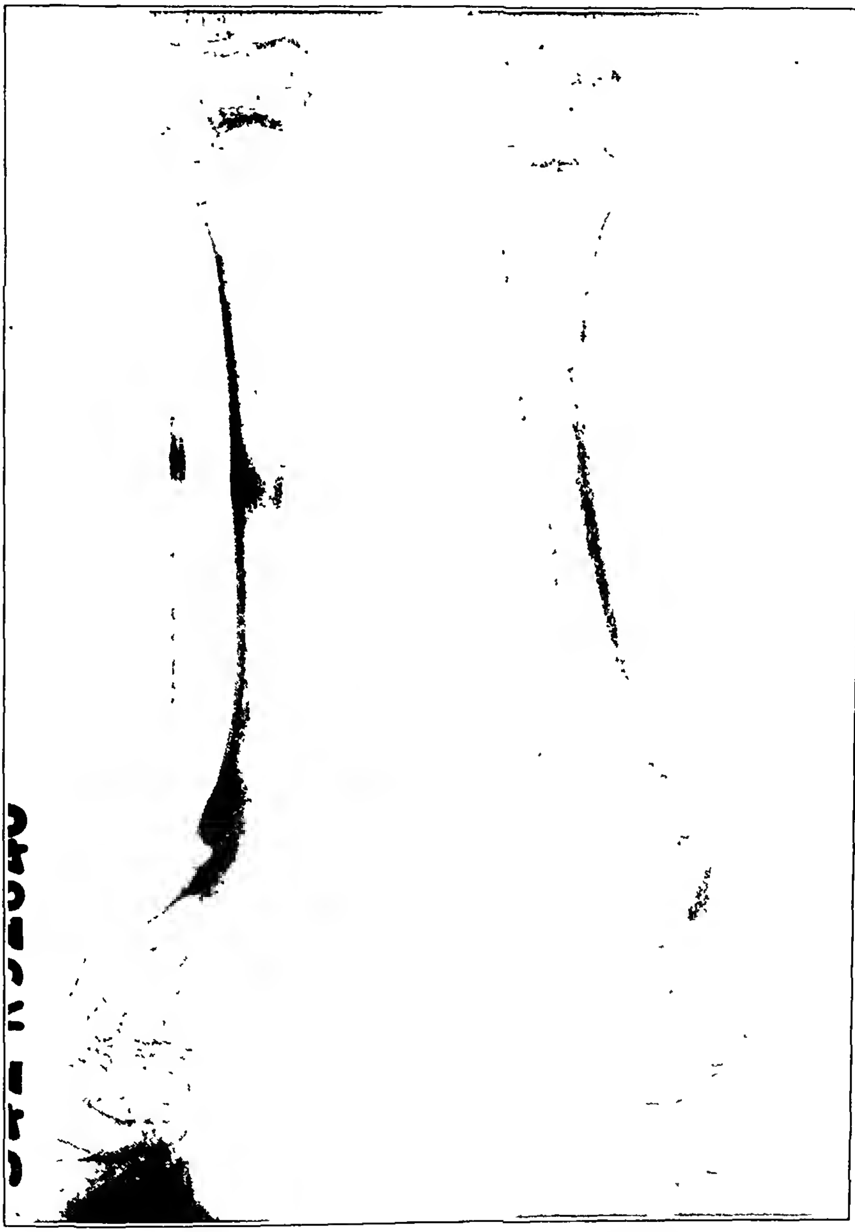

FIG. 23-A FIG. 23-B

Case 5. D. G. Roentgenograms of anteroposterior and lateral views taken September 23, 1940, show a complete non-union with slight attempt at callus formation at the site of the fracture shown in Figures 22-A and 22-B. The upper part of the tibia has straightened and shows very little evidence of the original non-union.

von Recklinghausen's disease (diagnosed at Mayo Clinic). Also, one of her own sisters has a child with pigmentation similar to that of the patient, but with no bone complication.

On examination, the leg showed rather marked outward and forward bowing of the tibia about three inches above the ankle joint. It was noted that it felt almost like an old fracture. There were no marked signs of rickets. She walked well and the legs were of equal length.

The roentgenograms taken at that time "showed a marked angular curve about two inches above the ankle joint. Judging from the sharpness of part of the curve this represents an old fracture rather than a rachitic deformity." We were suspicious of the deformity, and she was not admitted at the time. Later it was decided that the deformity was due to an old fracture, and, if it had healed once, it should heal again. This has proved very poor reasoning.

On September 12, 1929, an osteotomy was done and a cast applied. On March 30, 1930, she fell and fractured her right clavicle. This fracture healed easily and normally in less than a month but the tibia did not unite until eighteen months after the osteotomy. When it did heal, an inward curve developed at the site of the osteotomy. The leg was fractured again in December 1933, but healed in about six months. In September 1935, she developed puerpura hemorrhagica and was treated in the Medical Department at Northwestern University Medical School. On October 16, 1935, she fell and fractured the leg again about two inches below the original non-union. This last fracture has not yet united, though a bone graft was done on July 28, 1938.

Case 6. R. R. was first seen at Shriners' Hospital, September 20, 1929, when she was six years of age.

Birth and development were normal until she was eight months of age, when she

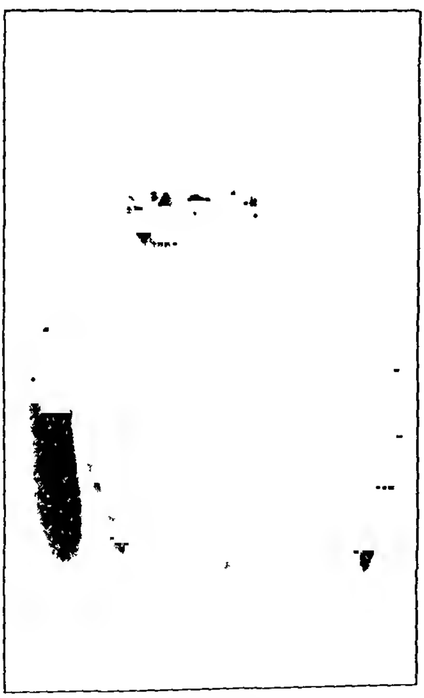

Fig. 24-A

Fig. 24-B

Case 5. D. G. Photographs taken January 17, 1940.

Fig. 24-A: Back view shows the pigmented area near the base of the spine which has persisted since the first picture. There is a group of pigmented spots between the scapula which are much smaller and resemble freckles though considerably larger.

Fig. 24-B: Front view shows the same pigmented area on the upper right arm. This area is near the edge of a large irregular area of light pigmentation.

fell off the bed and hurt her left leg. It was considered a sprain for three weeks, at which time a roentgenogram showed a fracture of both bones in the lower third of the leg. A cast was applied for two months. No union resulted and an open operation was done, also without union. She has worn a cast or brace ever since without any union. She can walk with the support but not without it. The mother has Von Recklinghausen's disease of the fibroma molluscum type.

Examination showed mobility at the junction of the lower and middle thirds of the left leg. All four ends of the fragments could be palpated. The left leg was approximately seven centimeters shorter than the right. There were several definite elliptical areas of brownish pigmentation on the body, arms, and legs.

The roentgenogram showed "a complete ununited fracture of both bones about three inches above the astragalotibial joint. The fragments were all sharply pointed. There was moderate atrophy of all the bones of the foot and leg."

Four operations including a transplant of heterogeneous bone and an onlay graft from the normal fibula were done between 1929 and 1936, all without union. On May 5, 1936, the leg was amputated about five inches below the knee and an artificial leg eventually fitted. At the time of the operation the nerves of the amputated portion were inspected. The posterior tibial nerve appeared somewhat larger than normal, but did not feel nodular, nor were the fibers convoluted. However, a later microscopic examination revealed a very interesting type of neurofibroma in which there was a marked increase of the fibrous tissue in the nerve bundles, but in only a few of them had the fibrous tissue entirely displaced the nerve tissue. Yet in these there was seen the typical structure of a neurofibroma. The nerve was sectioned at different levels and the appearance varied as shown in the photomicrographs. Even in the specimen in which the neurofibromatous changes seem relatively mild there is evidence of the endarteritis noted in the previous cases.

Fig. 25

Case 6. R. R. Photograph taken on admission in 1929 shows marked shortening and deformity of the lower left leg. Several pigmented areas are shown. There is one prominent one on the abdomen, also fainter ones below the left elbow, below the axilla, and at the ankle. The pigmentation at the knees is discoloration from creeping.

Case 7. E. B., aged two and one-half years, was admitted to Shriners' Hospital, March 22, 1935, with the complaint of deformity of the left leg near the ankle, and motion at the point of deformity. The mother stated that the leg had been the same way ever since he was born, but she did not know whether it was broken at the time of delivery or not. She said he did not seem to have any pain. He has been learning to walk recently, the bowing has been increasing, and the leg becoming shorter. The mother had numerous molluscous tumors on her face and arms. The child had several rather indistinct areas of light brownish pigmentation on the skin of his chest, though on recent examination these could not be found. We feel, however, that the association of maternal affliction and the bone condition warrant the assumption of neurofibromatosis.

On examination, the left tibia showed a marked anterior curve in the lower third. The apex of the curve was also a point of motion, and a little crepitus could be felt occasionally but not constantly. There was no evidence of pain on any reasonable amount of motion.

The roentgenographic report stated "there is a complete fracture of both bones in

Fig. 26-A Fig. 26-B

Case 6. R. R. Roentgenograms of anteroposterior and lateral views of the left leg taken on admission September 20, 1929, show complete non-union of both bones. All the fragments have the typical sharp points of pseudarthrosis. There is a slight periosteal reaction at the tips of the upper fragments. The tibia shows several transverse dark lines near the upper end of the diaphysis. The atrophy of the bones is moderate. There is a typical "cod-liver-oil" line at each epiphyseal line.

the lower third and an equally complete non-union. The fragments are all very sharp pointed."

Only one operation has been done and it was completely unsuccessful. The child walks in supportive apparatus. Remembering Henderson's observation that there is a better chance of success by operative measures at the time of adolescence, we are hoping to keep the bone in good condition by use until that time.

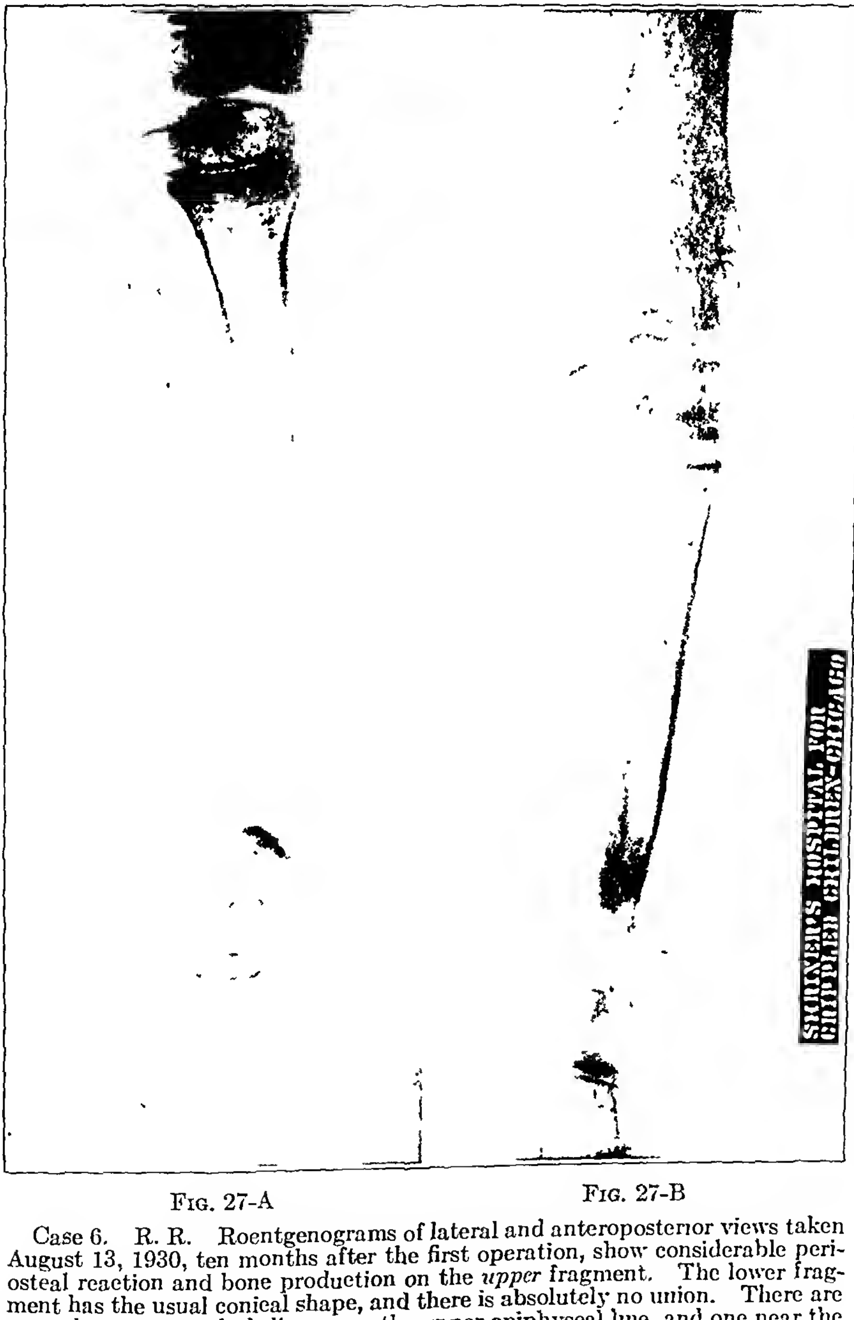

FIG. 27-A FIG. 27-B

Case 6. R. R. Roentgenograms of lateral and anteroposterior views taken August 13, 1930, ten months after the first operation, show considerable periosteal reaction and bone production on the *upper* fragment. The lower fragment has the usual conical shape, and there is absolutely no union. There are several transverse dark lines near the upper epiphyseal line, and one near the middle of the shaft.

DISCUSSION OF PSEUDARTHROSIS CASES

In this group of cases the bone lesion is of an entirely different type from the group of hypertrophies, yet there are similarities. All but one showed the typical pigmentation. There was a definite segmental relationship between the bone lesion and the neurofibroma in the one case we have been able to study histologically. This segmental relation-

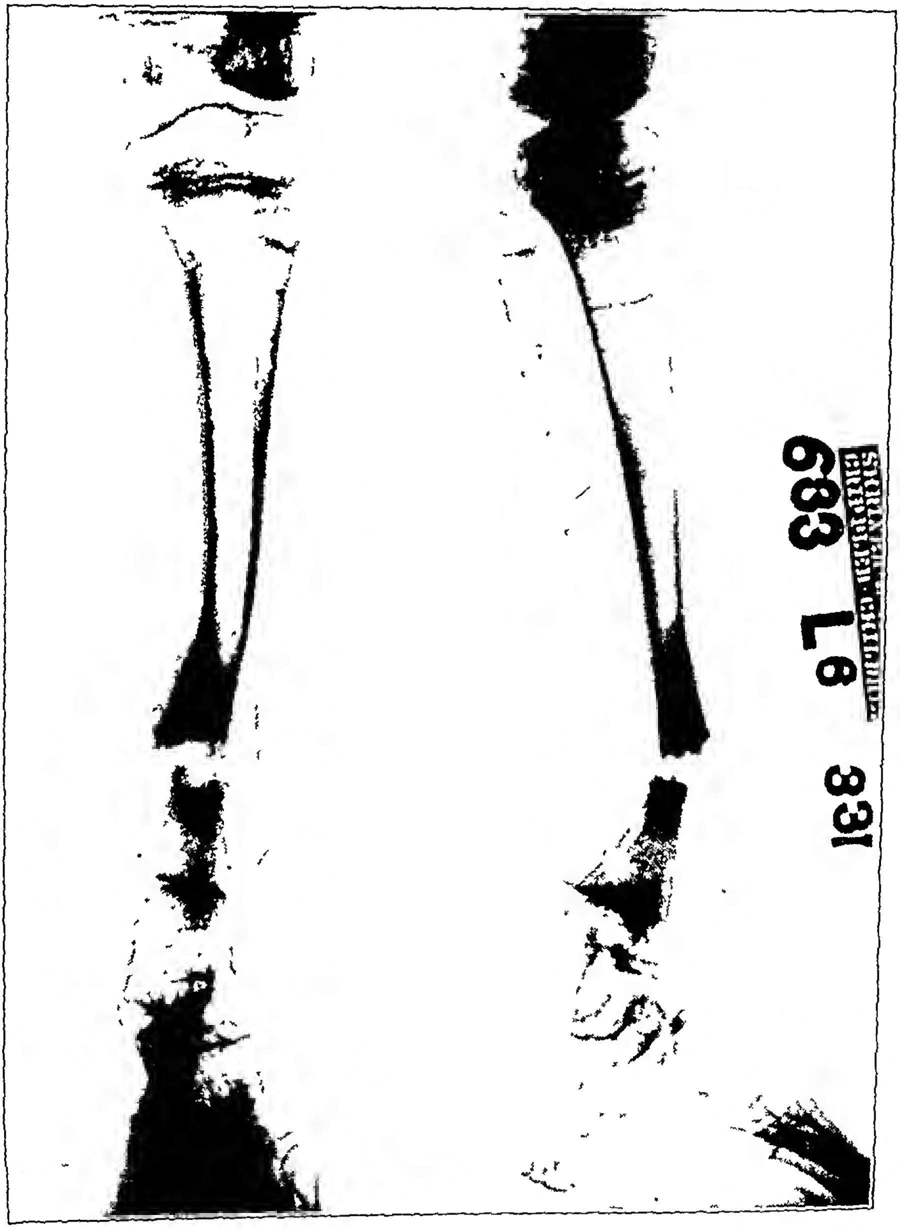

Fig. 28-A Fig. 28-B

Case 6. R. R. *Roentgenograms* of anteroposterior and lateral views taken June 3, 1931, six months after the third operation (heterogeneous bone graft). There has been considerable bone production at the lower end of the upper fragment. The lower fragment is now squared at the end, and there is end-to-end apposition, but no union. The bone appears to be of fairly good quality.

ship is hinted at in the normal healing of the fractured clavicle in Case 5 as compared with the non-union of the tibia.

In the discussion of the previous group of cases we expressed our

FIG. 29-A FIG. 29-B

Case 6. R. R. Roentgenograms of lateral and anteroposterior views taken December 4, 1935. The bone fragments have now become sharp-pointed again, and the shaft is much narrowed. The bones of the foot are becoming distorted. This deformity we ascribed to the fact that for about ten years she had been wearing some form of supportive apparatus,—usually a cast with an extension bar.

DISCUSSION OF PSEUDARTHROSIS CASES

In this group of cases the bone lesion is of an entirely different type from the group of hypertrophies, yet there are similarities. All but one showed the typical pigmentation. There was a definite segmental relationship between the bone lesion and the neurofibroma in the one case we have been able to study histologically. This segmental relation-

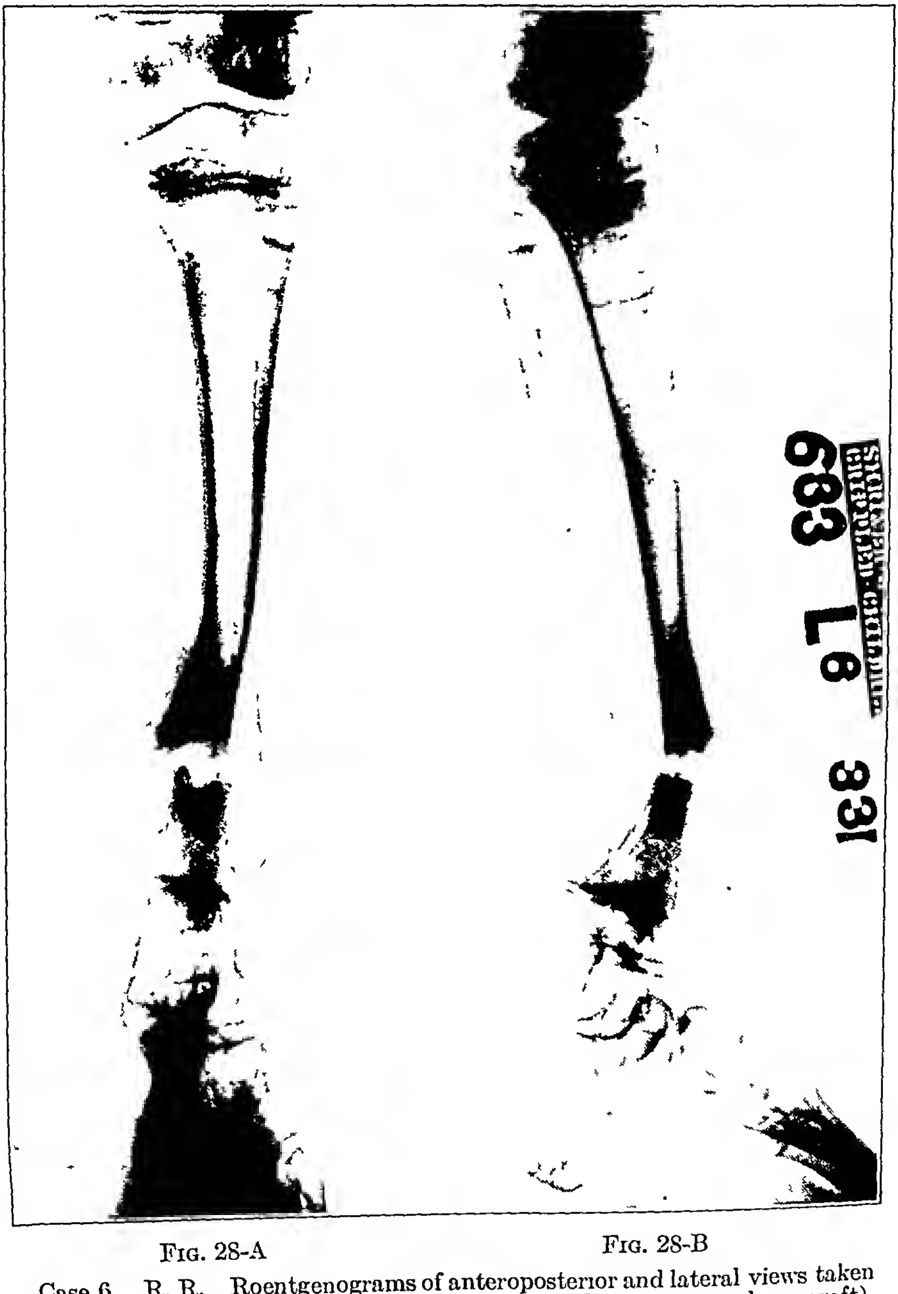

FIG. 28-A FIG. 28-B

Case 6. R. R. Roentgenograms of anteroposterior and lateral views taken June 3, 1931, six months after the third operation (heterogeneous bone graft). There has been considerable bone production at the lower end of the upper fragment. The lower fragment is now squared at the end, and there is end-to-end apposition, but no union. The bone appears to be of fairly good quality.

Fig. 31

Case 6. R. R. Medium-power enlargement of fasciculus seen in the upper right quadrant of the first section (Fig. 30), showing background of reticulated tissue from which nerve fibers have almost disappeared.

Fig. 32

Case 6. R. R. High-power photomicrograph of the same area as shown in Figure 31 shows details of fibrous infiltration. The fibrous tissue is apparently endoneural. The irregular dark spots are probably "gitter cells" with ingested degenerated myelin.

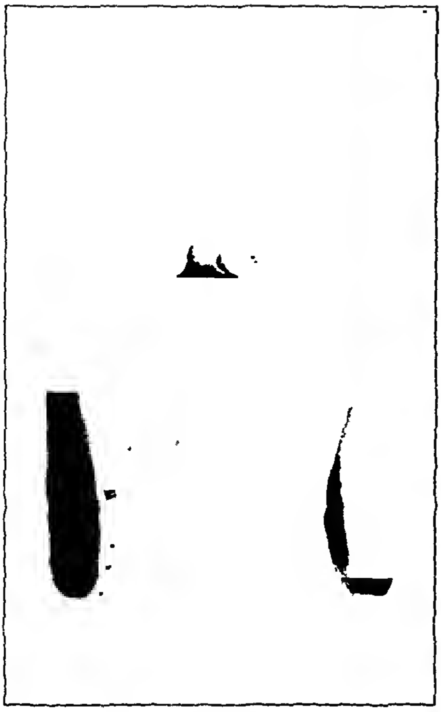

FIG. 33-A

FIG. 33-B

Case 6. R. R. Photographs taken January 17, 1940, showing the pigmented areas. The face also shows pigmentation which was present from the beginning.

the nerve injury is the immediate cause or whether it acts through a series of mechanisms, it still has an effect on the processes of the part affected. We believe, therefore, that the condition of the nerve and the pseudarthrosis stand in the relation of cause and effect, though the mechanism of the production is not entirely clear.

SUMMARY AND CONCLUSIONS

We have considered two very diverse orthopaedic conditions, both of which are associated with neurofibromatosis. Considered superficially, these two conditions are about as much alike as black and white. As we have said previously, the neurofibroma itself is unobtrusive, and the associated pathology is the condition which attracts attention to itself, from both the patient and the medical man.

We have expressed our opinion that the bone changes we have studied in these cases are all due to lack of control of the ordinary growth processes of bone. Under this general heading of uncontrolled growth we would classify the changes found as follows:

1. Hypertrophy, or overgrowth, as illustrated in the increase in length of members.
2. Hypotrophy, or underdevelopment as illustrated in the small tarsal bones in Cases 3 and 4.
3. Distortions of growth as shown by the vertebrae in Case 4.
4. Changes in the constitution of bone as exemplified by its failure to unite after fracture.

These four changes seem to include the bone changes as we see them, both in our own cases and in others described in the literature. The changes seen in a case may fit into more than one of these classes.

We believe that these bone changes are not merely associated with, but are the result of, the changes in the nerve either directly or indirectly. The reason for this belief is the frequency of the signs of neurofibromatosis associated with the types of deformity we have studied. However, the converse that these deformities always accompany signs of neurofibromatosis does not hold good. The most convincing argument for the causal relationship is the segmental localization of the deformities. This holds good not only in our cases but in many reports in the literature. The finding of definite endarteritis, to which we have called attention, is of special interest. We believe that it is a fairly constant finding. One point of interest is the effect that such an endarteritis might have on other organs. For instance in the brain it might account for mental changes which frequently accompany neurofibromatosis. Again, if it occurs in the arteries supplying any of the ductless glands, it is quite conceivable that dysfunction might result in that particular gland and a peculiar chain of symptoms be initiated. This may account for much of the rather indefinite endocrine symptomatology. Still another point of interest in this finding of endarteritis is whether it may furnish a clue to what we have called the uncontrolled growth of parts of the body. The arteries are under the control of the autonomic nervous system. May not this system also have some control of the normal pattern of body growth? We must admit we do not have enough evidence to advance it as an hypothesis but the idea is intriguing.

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UNUNITED FRACTURE OF THE NECK OF THE FEMUR TREATED BY HIGH OBLIQUE OSTEOTOMY *

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Despite the fact that in recent years the internal fixation of new fractures of the neck of the femur has stimulated renewed interest and achieved far better results than heretofore, there still remain a large number of cases, which, because of the failure of the surgeon to make use of these methods or because of the failure of the method, go on to non-union. Because of the frequent incidence of non-union, many procedures have been advocated for its relief, most of which have proved to be a boon for these patients. These operations have been divided roughly into two groups,—those which are termed reconstruction procedures, such as the Whitman, Colonna, and Brackett operations, and those which aim to restore the anatomical and physiological relationships of the hip joint, such as the Albee bone-graft method, and the operations described by Gallie and Lewis, Dickson, Compere and Lee, Magnuson, and King.

Since all these methods have been widely employed and extensively reported, there is no need to go into detail concerning their relative merits or the individual operative procedures. However, each one of these methods involves extensive operative technique, which in many instances results in postoperative shock and hemorrhage, and good end results are dependent upon many factors of which a meticulous operative technique is of utmost importance.

In a recent article Colonna has divided ununited fractures of the neck of the femur into two groups: (1) those in which there is a viable head; and (2) those in which the head has undergone aseptic necrosis. He has stated that the reconstruction type of operation, such as he advocates, is indicated only for those individuals in whom the ununited head is not viable. It would be fair to postulate, therefore, that these indications would apply also to the other reconstruction operations, which are predicated on the principle of the removal of the ununited head and the implantation of the remaining neck or trochanter. Although there are no exact statistics available, it is safe to say that by far the larger proportion of ununited femoral heads are viable. King, in his excellent and comprehensive review of both recent and old cases, emphasized two important points. (1) A three-weeks-old fracture can be arbitrarily called old and ununited, as it can be assumed that the head of the femur, detached from its blood supply, has less chance of osseous union, and that secondary changes are more probable than if operation were performed earlier. (2) Out of fourteen ununited fractures treated within three months by extra-articular osteosynthesis with a Smith-Petersen nail, osseous union was obtained in

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64.3 per cent., but in almost half a severe osteo-arthritis developed. Of sixteen ununited fractures treated within two years by extra-articular osteosynthesis with a Smith-Petersen nail and whole-thickness fibular peg, osseous union was obtained in 68.75 per cent. and in nearly one-third osteo-arthritis of a moderate form developed.

In 1922 the writer had the opportunity of studying patients with ununited fracture of the femoral neck on whom an oblique osteotomy had been performed by Hass. The operative procedure appeared so simple, compared to the other popular methods, and the results so excellent that this method has been employed in all suitable cases,—namely in those individuals in whom the head of the femur was viable. This paper is a report of twenty-six patients who were operated upon.

INDICATIONS

All cases in which there had been no reduction, or in which the reduction had been unsuccessful, were considered suitable for this method if the head was demonstrated roentgenologically to be viable. Notwithstanding the fact that King designates a three-weeks-old unreduced fracture as ununited, the shortest interval between incidence of fracture and osteotomy in our series was six weeks. This method was contra-indicated in those cases in which definite aseptic necrosis or osteo-arthritis of the ununited head had developed and in those in which the patient's general physical condition was of such a serious nature as to preclude any type of surgical operation, even one as simple as the osteotomy.

Before describing the details of the operative technique, it may be well to discuss the principles on which the high oblique osteotomy is predicated. It is readily agreed that the shearing force of the fractured femoral neck on the head is the primary factor in the causation, not only of the fracture itself, but also of the deformity. This shearing force is also a very important factor in the eventual end result, regardless of what treatment is employed for the recent fracture. The first objective, therefore, in the osteotomy is to overcome this shearing force as far as possible, so that the fractured head assumes a position more or less on top of the neck instead of lateral to it. Secondly, in addition to overcoming this shearing force, the original osteotomy has been modified in such a manner that when the distal fragment is displaced inward, a portion of the head rests directly upon it, so that it acts as a direct source of weight-bearing. Moreover, the head is in direct approximation to the shaft, thus shunting off the femoral neck.

SELECTION OF ANAESTHESIA

It has been the writer's practice to perform the osteotomy under general anaesthesia and the anaesthetic of choice has been avertin, in the dosage of approximately 80 to 85 milligrams per kilogram of body weight. For most of these cases this was sufficient to carry the patient through the entire operative procedure, but in some instances it was necessary to sup-

plement it with nitrous oxide and oxygen anaesthetic or with novocain block. Where there was a contra-indication to the use of avertin either nitrous oxide and oxygen or a spinal anaesthetic was employed.

OPERATIVE TECHNIQUE

The roentgenogram is studied to determine the degree of coxa vara and consequently the relation of the neck to the ununited head. If there is a marked coxa vara due to excessive upward displacement of the greater trochanter, it may be necessary, as a preliminary procedure, to apply traction to the leg for a sufficient period to restore the relation of the neck to the head, or at least to the position it assumed immediately after the occurrence of the fracture. It is not essential to reduce completely the coxa vara before the osteotomy is performed.

Since it is necessary to immobilize the patient in a plaster-of-Paris hip spica following osteotomy, the operation must be performed on a fracture table with both feet fastened to the stirrups in slight abduction, and with moderate internal rotation of the fractured limb. Some of the shortening, if still present, should be overcome by traction exerted on the fractured limb with the aid of the fracture table before the level of the osteotomy is determined, because the osteotomy should be performed through or above the lesser trochanter.

When the relationships are found to be favorable, the osteotomy is performed as follows: A lateral incision is extended from the prominence of the greater trochanter downward for approximately three inches, similar to that employed for extra-articular osteosynthesis with the Smith-Petersen nail, and the femur is exposed. To salvage as much of the length of the femur as possible, and to implant the lesser trochanter under the femoral head, the site of the osteotomy must be accurately determined. After the upper shaft of the femur has been exposed, a Kirschner wire, Steinmann pin, or metal screw is inserted through the site and in the direction of the proposed osteotomy, and an anteroposterior roentgenogram is obtained to determine the exact level of the osteotomy (Figs. 1-B and 1-C). This position should, if at all possible, be in the intertrochanteric space so that the inner portion of the osteotomy is just above or through the lesser trochanter. By means of a sharp osteotome the osteotomy is now performed in the horizontal plane with the osteotomy pointing upward and assuming an angle of approximately 20 to 30 degrees with the shaft of the femur. When the proximal and distal fragments have been completely divided, the distal portion of the osteotomy is pushed inward approximately one-half inch, according to the method described by McMurray for the relief of arthritis deformans of the hip joint. After the distal portion has been forced inward, the thigh is then abducted to an angle of approximately 30 degrees, the amount depending upon how satisfactorily the distal fragment has been displaced inward. There is a particular advantage in performing the osteotomy above the lesser trochanter if at all possible, as McMurray has shown, because the muscle

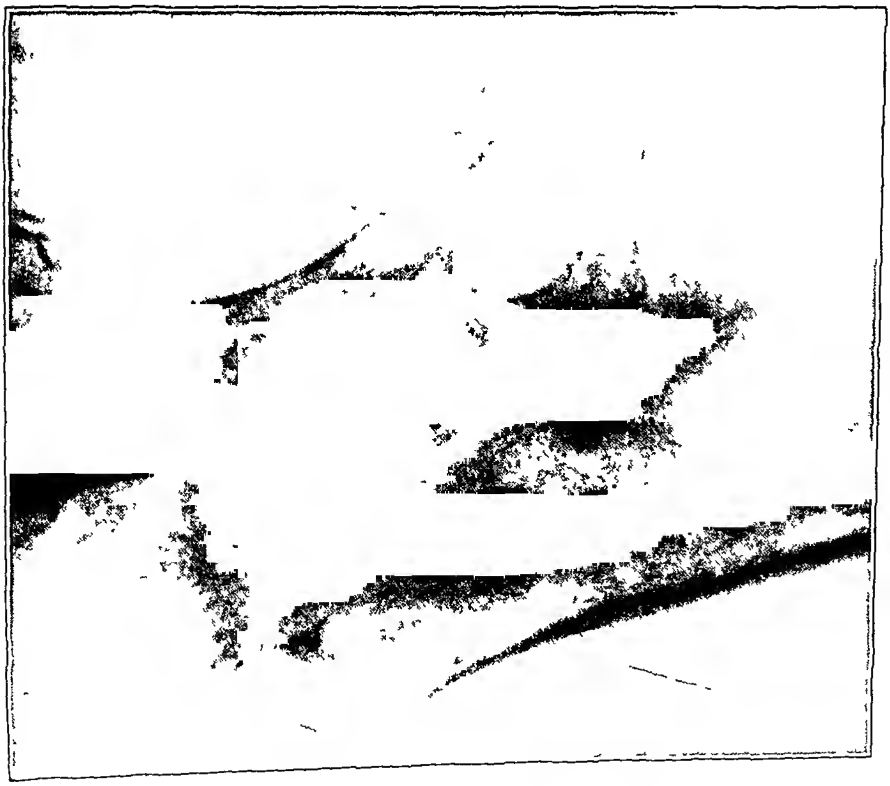

Fig. 1-A

Roentgenogram, taken August 15, 1938, of ununited *fracture* of the femoral neck of one year's duration.

Fig. 1-B

Roentgenogram, taken September 3, 1938, showing Steinmann pin at the site of the proposed osteotomy to determine accurate course and level of the osteotomy.

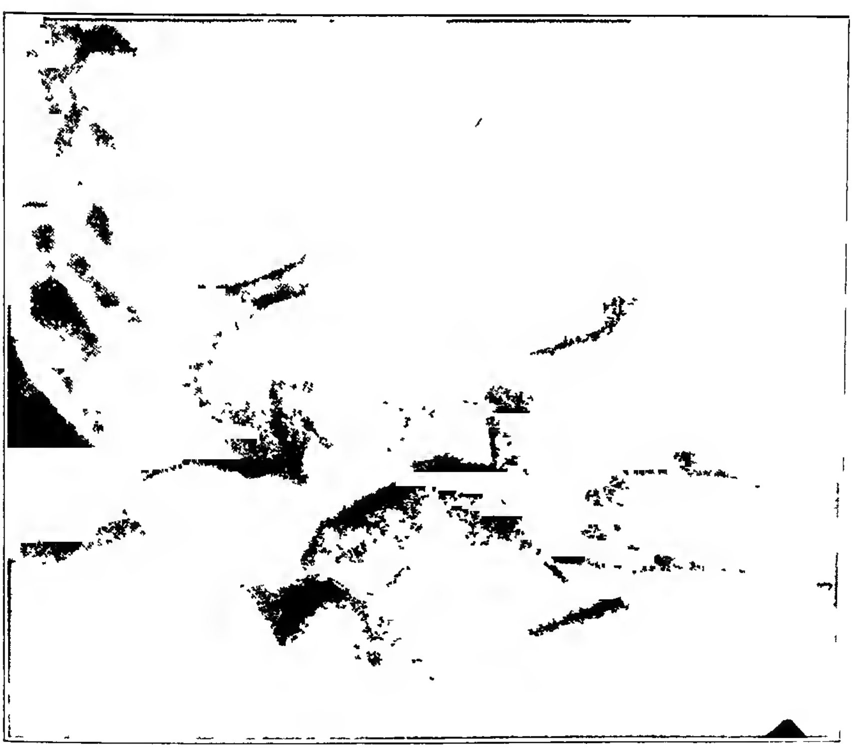

Fig. 1-C

Roentgenogram, taken September 10, 1938, of osteotomy carried through the course designated by the Steinmann pin.

Fig. 1-D

Roentgenogram, taken April 1, 1940, showing high oblique osteotomy and union of a previously ununited femoral neck.

attachments to the lesser trochanter assist in displacing the distal fragment inward by their pull. It is important that the osteotome divide the upper femur into two complete upper and lower fragments, without any secondary fragments being broken off. Otherwise a protruding piece of bone, either from the proximal or distal fragment, may prevent this inward displacement of the distal fragment. The wound is then closed, and a plaster-of-Paris hip spica is applied with the femur in abduction of approximately 30 degrees and with the hip and knee in slight flexion. It is important to accomplish this abduction with the requisite pressure exerted on the thigh, and not on the knee or the leg below the knee.

The osteotomy is checked by roentgenograms a few days after the operation to ascertain its position, and, if unsatisfactory, remanipulation is carried out. Six weeks after the osteotomy another roentgenogram is obtained, this time to determine the degree of callus formation. In a preponderance of the author's cases there was sufficient callus demonstrable after this period to permit removal of the hip spica. If the roentgenogram does not demonstrate adequate callus formation, the osteotomy is rechecked in two weeks, and almost invariably there is sufficient healing at this time to permit the removal of the external fixation.

The patient is now immediately allowed up on crutches, and is encouraged to bear weight. Whatever residual shortening there may be is compensated for by an elevation of the heel and the sole. As soon as feasible, the patient is referred for physiotherapy, and he receives massage, muscle training, and active motion, with gradually increasing passive manipulation of the hip and if necessary also of the knee. The crutches, and the cane which is employed thereafter, are both discarded as soon as possible.

In determining the end results of the high oblique osteotomy in patients on whom it has been performed, the following factors have to be considered:

1. Hip function, which should include sufficient range of motion in the hip joint to permit the patient to dress and, particularly, to put on his shoe and stocking.
2. Knee function, which contributes to good hip function.
3. The degree of shortening.
4. The amount of residual pain and discomfort.
5. Union of the ununited fracture, which is necessary for optimum function.
6. The degree of postoperative shock.
7. The incidence of infection.

DISCUSSION

In the series of twenty-six patients operated upon, the ratio of females to males was two to one. The ages ranged from fifty-seven to seventy-nine years. The greatest period of non-union was two and one-half years, and the shortest six weeks. One patient we were unable to locate to

FIG. 2-A

Roentgenogram, taken May 30, 1939, of ununited fracture with coxa vara following Smith-Petersen nailing.

FIG. 2-B

Roentgenogram, taken August 3, 1939, showing reduced coxa vara and high oblique osteotomy.

evaluate the end result. There was only one death, which occurred three weeks after the osteotomy, from a cerebral complication in a seventy-three-year-old female patient, with Parkinson's disease. The high oblique osteotomy was considered to have failed in three of the twenty-five patients. In one patient there appeared to be an increase in the original non-union of the neck in spite of the fact that the osteotomy had healed in a satisfactory position. This failure may have been due to the fact that the osteotomy was too high and actually displaced the head too far upward. In another patient, a male with Parkinson's disease, there are considerable restriction of motion, complaint of pain, and difficulty in locomotion, partly due to the patient's illness. Of the twenty-two remaining cases, it is interesting to note that the earlier these patients were operated upon following the original fracture, the more rapid was the convalescence, and the greater the restoration of function of the hip and the knee. All have resumed their former gainful occupations and are able to get about with very little difficulty or discomfort. In none of these patients to date

FIG. 3-A

Roentgenogram, taken July 26, 1939, of ununited fracture of the neck of the femur of two-and-one-half years' duration.

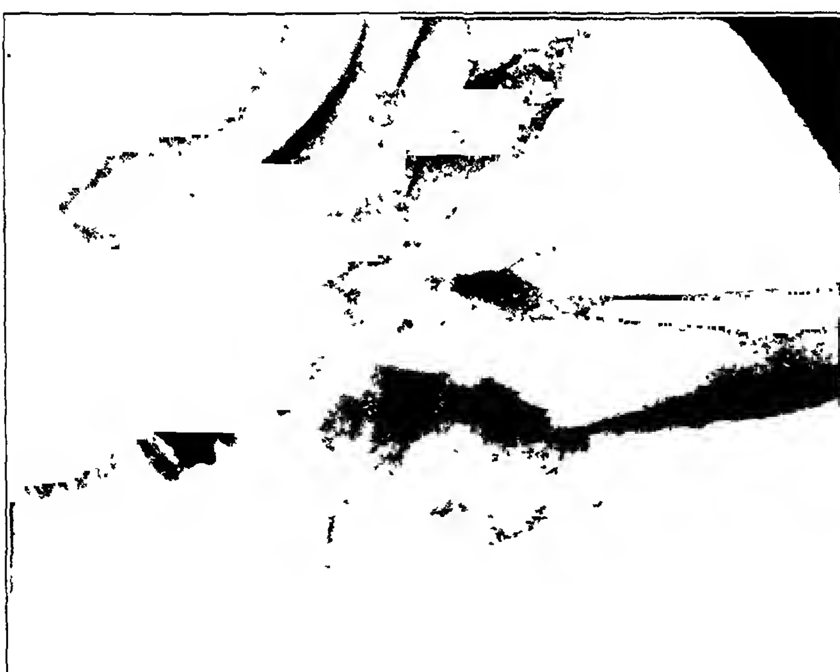

Fig. 3-B

Roentgenogram, taken October 13, 1939, showing high oblique osteotomy and reduced degree of coxa vara. Compare with Fig. 3-A.

Fig. 3-C

Roentgenogram, taken December 26, 1939, showing union of osteotomy and previously ununited femoral neck.

Fig. 4-A

Roentgenogram, taken April 23, 1938, showing apparent union of fractured femoral neck six months after injury.

Fig. 4-B

Roentgenogram, taken October 27, 1938, showing definite non-union with coxa vara one year after injury.

FIG. 4-C

Roentgenogram, taken February 10, 1939, of high oblique osteotomy, showing the head implanted directly on the top of the lesser trochanter, thus completely overcoming shearing force.

FIG. 4-D

Roentgenogram, taken March 21, 1939, showing union of the osteotomy and the neck.

FIG. 5-A

Roentgenogram, taken August 26, 1938, of anteroposterior view of ununited fracture of the femoral neck with coxa vara.

FIG. 5-B

Roentgenogram, taken December 12, 1938, of semilateral view indicating non-union.

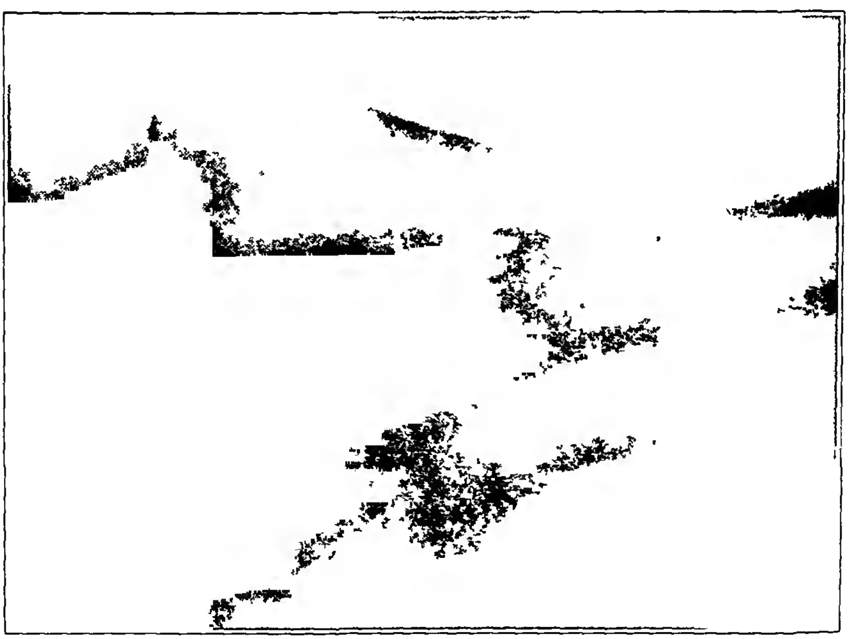

Fig 5-C

Roentgenogram, taken January 16, 1939, of high oblique osteotomy, showing the lesser trochanter under the head of the femur.

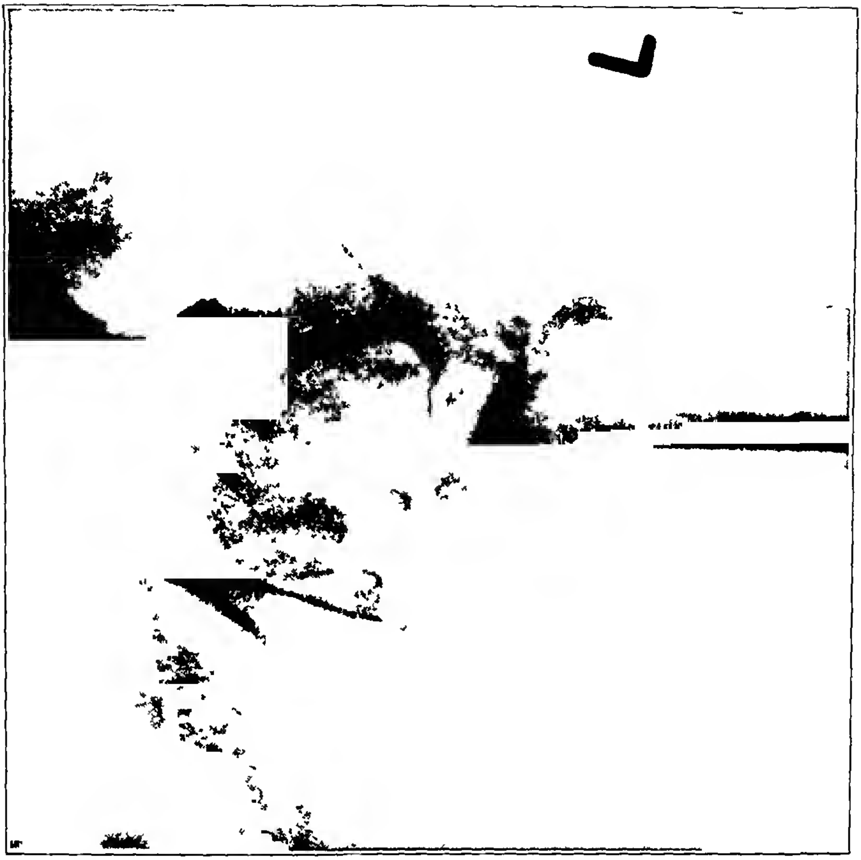

Fig 5-D

Roentgenogram, taken June 12, 1939, showing healed osteotomy and femoral neck with head directly on top of the lesser trochanter.

Fig 6-A

Roentgenogram, taken January 16, 1940, showing fracture of the neck of the femur with coxa vara of six weeks' duration

Fig 6-B

Roentgenogram, taken April 6, 1940, of high oblique osteotomy, showing coxa vara completely corrected with lesser trochanter directly under the head

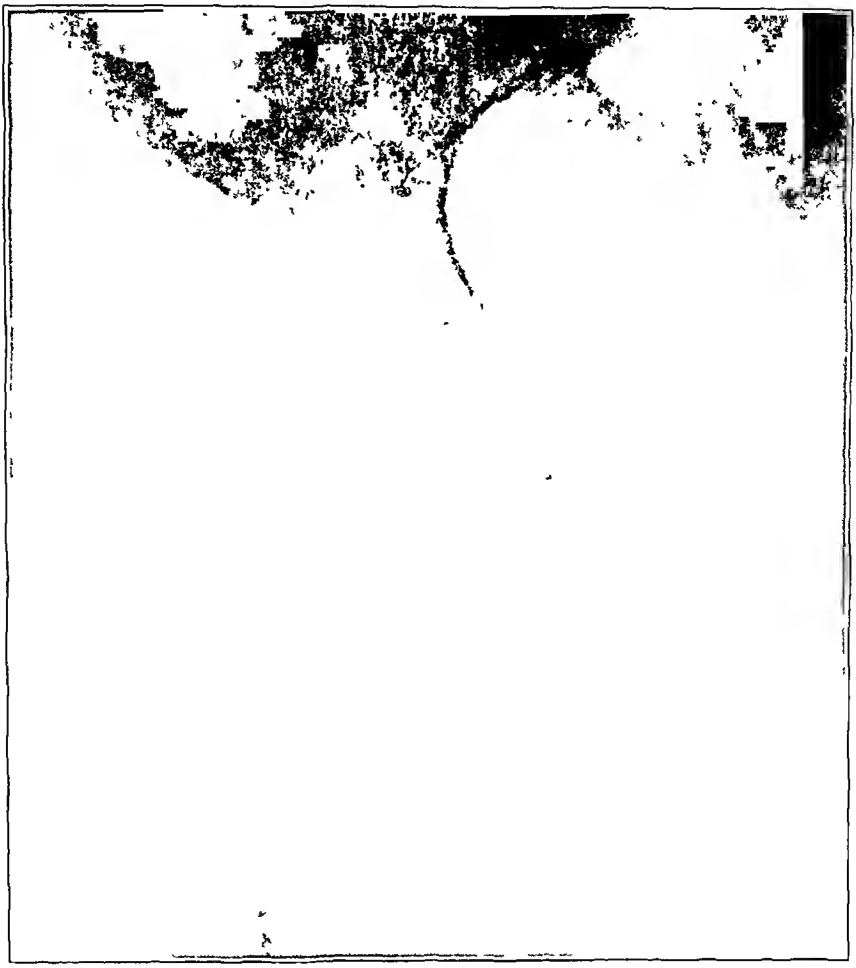

Fig. 6-C

Roentgenogram, taken August 17, 1940, showing union of osteotomy and femoral neck with the head and trochanters in excellent relation to the shaft.

has there been any evidence of secondary osteo-arthritis or aseptic necrosis.

Hip Function. All but one of the twenty-two patients had at least 75 degrees of flexion of the hip; this one had 60 degrees. The greatest amount of flexion was 110 degrees. In each of these individuals there was approximately 45 degrees of external and internal rotation of the thigh. Abduction averaged approximately 20 to 45 degrees, and adduction averaged 30 degrees.

Knee Function. The longer the period of time that had elapsed between the original fracture and the osteotomy, the greater the restriction of motion in the knee. In many of these patients, there was marked restriction of motion before the osteotomy was performed. However, in each of these individuals knee function has been restored to a great extent, and, with the aid of well-planned and properly directed physiotherapy, in many instances it has been restored completely.

Shortening. It is the opinion of some of the observers that leg length is sacrificed and consequently shortening is increased following a high oblique osteotomy. In the writer's experience this has not been the case. When the osteotomy is performed at the desired level, the ununited head, which is in coxa vara, is frequently rotated upward by pressure from the lesser trochanter, and is actually replaced in its anatomical position (Figs. 2-A, 2-B, 6-A, and 6-B). When the osteotomy is performed through the intertrochanteric space, the obtusity of the angle formed by the neck and the shaft is increased, so that the hip joint somewhat resembles the upper end of the humerus, and leg length is consequently increased. In the writer's series the greatest amount of shortening was one and one-fourth inches and the least, three-eighths of an inch.

Pain. Of the three patients in whom the operation failed, two had considerable pain; the remaining twenty-two patients had varying degrees of pain in the hip and knee for an average of three months following the removal of the plaster-of-Paris spica. After this period the pain rapidly disappeared. A number of individuals complained of pain in the lower back, but this also gradually disappeared as function improved.

Union. In every one of the twenty-two cases with good end results there was a union of the ununited fracture, and in two of the three patients in whom the result was not satisfactory, there was questionable union (Figs. 1-A, 1-D, 3-A, 3-B, and 3-C). It is significant that callus was demonstrable between the osteotomized surfaces of the femur approximately six weeks following the operation in a preponderance of patients operated upon, and in the remaining patients two weeks later, thus permitting removal of the hip spica. By reason of the fact that the shearing force was eliminated, these patients were permitted to bear weight without any support. In one or two instances callus was demonstrated eight weeks after osteotomy, between the ununited head and neck and its distal point of apposition, but in most instances firm union was not evident much before three months following high osteotomy. This large incidence of union is quite remarkable and it is difficult to explain its causation. However, it is evident, as has been recently suggested by Wilson in discussing osteotomy following ununited fractures of the femoral neck in children, that the osteotomy plays a very important rôle in the revascularization of the neck, resulting in union. In the discussion of the end result of the effect of union following osteotomy, it is evident that the end result is far better in those patients in whom union of the ununited femoral head has been accomplished. Moreover, it is quite significant and, therefore, fair to assume that secondary changes such as aseptic necrosis and osteoarthritis are less likely to occur following osteotomy than after the other procedures advocated.

Postoperative Shock. As the operative procedure requires approximately twenty minutes for its performance, including the roentgenograms, and as there is very little operative hemorrhage, there should be no postoperative shock. In fact, none has yet been observed in our series.

Infection. The operative procedure entailed but a small incision and the minimum of tissue trauma, and all the wounds healed by first intention. There were no infections.

As the operation is designed to eliminate the femoral neck, the thigh is necessarily brought closer to the opposite side. Some patients, particularly the females, have complained of this difficulty, but this cannot be considered a serious contra-indication. A number of patients also complained of knock-knee. This occurred in very few instances, in those patients with greater shortening. When the shortening had been compensated, and knee-joint function improved, the patients were less conscious of this fact.

Some advocates of the reconstruction type of operation have emphasized the fact that their procedure is preferable because it does not require any form of external fixation such as a plaster-of-Paris spica, while the osteotomy necessitates bed confinement, and is particularly conducive to joint stiffness. This has not been the experience of the author because the plaster spica is applied with both the hip and knee completely relaxed and in slight flexion, and the abduction is achieved by forcing the distal osteotomy fragment inward rather than by abduction of the leg. As a consequence, the plaster-of-Paris spica is applied with no undue strain on the ligaments of the knee. The patient is placed in bed so that the foot hangs out, and thus permits him to be in a partial sitting position. It is the author's opinion that, unless there is an active knee-joint disease, there need be no fear of joint stiffness. Where one is apprehensive of any knee-joint stiffness because of osteo-arthritis or any other cause, a plaster-of-Paris spica may be applied with steel hinges incorporated in the plaster cast at the knee joint, thus permitting active and passive knee motion.

SUMMARY

In all cases of ununited fractures of the neck of the femur, where the head is viable, the high oblique osteotomy offers the simplest and most satisfactory method of treatment. By the operative technique described it is possible to determine the exact level of the osteotomy, thereby saving the length of the femur and ensuring security of the head on the end of the distal fragment. In a series of twenty-six patients treated by this procedure, twenty-two showed good results,—namely, satisfactory motion in the hip and knee, union of the ununited fracture, a minimum of shortening, and the ability to return to former occupations.

Whereas the osteotomy has been employed in the treatment of ununited fractures of the femoral neck since 1923, the first use of the high oblique osteotomy as described in this paper was in January 1935, and the last patient in this series was operated upon in January 1940.

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THE AUTOSYNOSTOSIS AS A SIMPLE METHOD OF SHORTENING THE BONE

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The choice of a method of equalizing the length of members of the body is frequently difficult. Since the operation for lengthening of the bones is a serious one, attended by many risks, the establishment of equality by the simpler method of shortening is preferred by many surgeons.

The operation for shortening the sound limb was first performed by Heine (Würzburg), but interest in it was not apparent until about the beginning of the present century. Since then, according to J. W. White[1], articles on its employment have been published in many countries. Previous to 1934, Dr. White performed forty-five operations for shortening the longer lower limb.

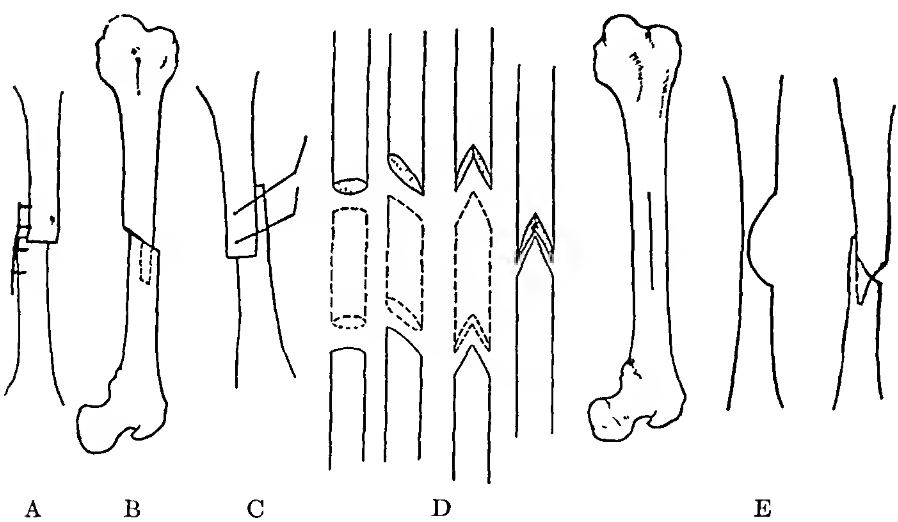

FIG. 1

Diagram showing various procedures. *A:* Deutschländer's; *B:* Calvé's; *C:* White's; *D:* Sorrel's; *E:* Kofmann's.

Defective limbs are frequently the result of muscle contracture or muscle wounds, or of contraction from injury to nerve trunks or roots, etc. In such cases there is distinct indication for surgical intervention to correct the defect or deformity. An operation may be indicated to correct defects as in Volkmann's ischaemic contracture, perhaps in combination with the operation on the contracted muscle, as reported by Sorrel. The question of shortening the sound limb has had much discussion, but the author shares the opinion that this means of length equalization is to be preferred to the lengthening of the defective limb since in the latter

Fig. 2-A

Case of manus vara. The distal end of the ulna is longer than that of the radius.

Fig. 2-B

After autosynostosis, the ends of the bones are at the same level.

there may be atrophy of scar tissue, contraction of muscle or tendons with adhesions, callus formation about the trunks of nerves, deformity of bone, and the result of old osteolytic changes, with the danger of retention of active germs and the possibility of infection.

Any operation for bone shortening should be simple and should give all possible assurance of successful union. However, this union may not always be obtained. In the author's experience, an oblique resection of a sound limb, performed twelve years ago, although surgically and postoperatively treated in the usual manner, failed to result in bony union, and secondary deformity developed.

Various methods of operating and of obtaining fixation have been reported. Deutschländer used aluminum plates, White overlapped the ends of the shortened bones and used pins, Calvé made an oblique cut, with a long quadrangular thorn at one end which he introduced into the marrow channel at the other end. For fixation he used strong catgut threaded through the bone. Sorrel employed "*resection en chevron*", introducing one sharpened end into a triangular cut at the other, strengthened by plates.

A communication of Dreyfus on the subject of camptodactylia, describing an operation to produce a stable contracture of the fingers by a method of shortening the bones of the hand. stimulated the author to follow this principle in a case of arthrogryposis.

The technique was simple. A long incision was made over the dorsum of the hand and the periosteum was incised for the greater part of its length, stripping it from around the sides of the two metacarpal bones. Then, with a sharp chisel, a four-centimeter incision was made along the shaft, leaving the cancellous portion with a thin part of the cortex.

The thin portion of the bone was then fractured and the fragments were pushed together to produce the desired amount of shortening, and the periosteum was closed with sutures.

The same operation was employed in a case of manus vara caused by an elongation of the distal end of the ulna, the result of an injury during childhood. In this case, resection of four centimeters at the distal end of the ulna was made, with fracture of the thin cortical area into the periosteal cuff; the fragments at the intersected portions were pushed into contact with each other.

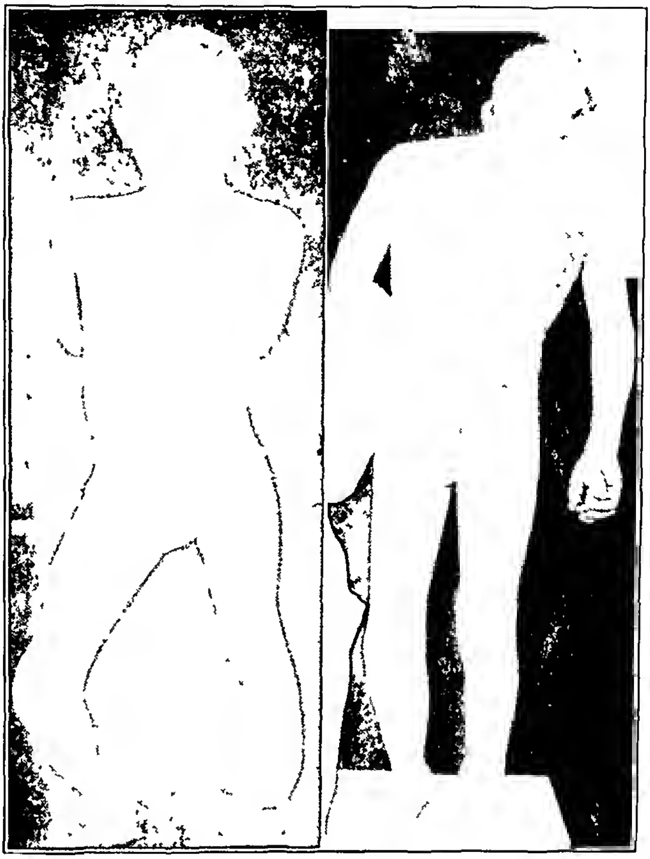

FIG. 3-A FIG. 3-B

Case of rachitic deformity, before and after operation.

The same method was applied in a third case, deformity resulting from a wound of the cervical plexus causing marked atrophy and paresis of the upper limb. The hand had the shape of the classic "*main en griffe*". Shortening of the metatarsals according to the method described brought about an improvement in the position and function of the fingers.

In a fourth case, a boy with rachitic deformity of both lower limbs, so extreme that the lower epiphysis pointed inward at a marked angle and the fibula showed an outward bowing with an increase in length, so that in standing the foot rested on the outer border of the external malleolus, an osteotomy of the tibia was performed; the fibula was shortened according to the author's method by an excision of a piece of bone four centimeters in length at its middle third; the thigh was corrected and the leg fixed in plaster in normal position.

By this method, the preservation of the periosteal cuff prevents the interposition of muscle tissue, and the insertion of one bone end into the other secures the union of the fragments. The operation is simple, and no special surgical instruments are required. The method is less difficult and gives greater surety of success than the methods usually employed.

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RADIATION TREATMENT OF GANGLIA OF THE WRIST AND HAND

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Ganglia occurring about the joints, and those involving tendon sheaths, are embarrassing deformities, and may cause pain and weakness of the joint. Some patients prefer prompt treatment. The ganglia may develop after injuries such as sprains, or insidiously without known trauma. The pathogenesis is, in my opinion, probably traumatic. This opinion is based on the microscopic pathology of thirty-two sections of tissue, removed at operation, which revealed two cases of round-cell infiltration, and one case of hemosiderin pigmentation in the wall of the ganglion and surrounding adherent adipose tissue. Other theories, however, include herniation of the synovial membrane through an area of weakness in the tendon sheath or joint capsule, and colloid degeneration of the synovial membrane. Roentgen-ray therapy has been used at The Presbyterian Hospital with very satisfactory results.

Twenty-one patients with ganglia were treated by this method, and six of these have been followed for five years. The condition occurred with approximately equal frequency in males and females,—males eleven, females ten. The duration of these tumors, before consultation with the doctor, ranged from six months to twelve years with the average about two and one-half years. The occupations of the patients were student (six), clerical worker (six), housewife (three), nurse (two), and lawyer, chef, laborer, and child (one each). All but two of the tumors were located in the wrist. The two exceptions were in the tendon sheaths of the thumb and first finger. Of the twenty-one patients, eighteen complained of pain, fourteen of the presence of the tumor, and eleven of weakness of the joint.

The size, duration, and previous treatment of the tumor generally dictated the number of roentgen-ray treatments required to relieve the symptoms. Eight patients received only one treatment; one received seven, and another eight; the average number was nearly three. Of the eight patients who received one treatment, five were relieved of symptoms and three failed to return. Questionnaires answered stated that one of the three was not helped, but that the other two were slightly benefited by the treatment. The dosage of roentgen ray administered was 1.5 erythema immediately over the tumor. The patients were told to return in one month. If the tumor had disappeared and all symptoms were relieved, one treatment was considered suffieient. Where the tumor persisted, 1.5 erythema of radiation was given each month until results were

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obtained. If more than five treatments are necessary, the interval between treatments must be more than one month.

The tumor in the cases requiring seven and eight treatments gradually decreased in size, and increased in resistance to palpation. The actual process was one of fibrosis and destruction of endothelial secreting cells.

The value of the roentgen-ray therapy is revealed by the results of examinations and questionnaires. Seventeen, or 81 per cent., of the tumors had disappeared; fourteen, or 78 per cent. of those complaining of pain were relieved; and nine, or 82 per cent. of those complaining of weakness had normal return of function in the joint. In general, seventeen had good results, one was improved, two were not improved, and one was not heard from.

The author believes that this method of treatment is superior to the various procedures used in the past, and warrants a more extensive use. Ganglia which are aspirated or treated by the injection of a sclerosing solution such as sodium morrhuate, tend to recur. The old method of striking the tumor with the family Bible does not appeal to the patient's fancy, and seldom produces a cure. Surgical excision has produced the best results in the past with the least number of recurrences.

The advantages of roentgen-ray therapy over other procedures of treating ganglia are:

1. A higher percentage of cures is obtained.
2. There is no resulting scar.
3. Hospitalization is not required.

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OSTEOPATHIA CONDENSANS DISSEMINATA

Osteopoikilosis (Spotted Bones)

Report of a Case

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Osteopoikilosis, a disseminated condensing osteopathy sometimes called osteopecilia or Albers-Schönberg disease, is a congenital anomaly which is probably hereditary in nature. It occurs without symptoms, is seen in both sexes, and has been reported in every bone. It is usually diagnosed by chance when noted during roentgenographic examination for some other disorder. We were able to find fifty-two cases reported in the literature, but see no need for a detailed review at this time since Lowrey and Booth [8] have recently made an excellent survey of the literature, and listed a complete bibliography. Albers-Schönberg [1] is generally credited with having reported the first case in 1915. Roentgenograms of his patient, a twenty-one-year-old white male, revealed rounded or oval areas of spotted condensation in the spongiosa of the bone. Bloom [2] credited Stieda [14] with having described the condition in 1905 when he reported both roentgenographic and miscroscopic findings that are in keeping with the present concepts of the disease.

ETIOLOGY

The congenital origin of the disease has been well established. Von Bernuth [19] demonstrated the changes in a child eighteen days after birth. Heilborn, in discussing a report of Steenhuis [13], stated that he had seen the condition in a four-months-old foetus. Keyser, in discussing the same paper, stated that he had seen the changes in a child a few days old.

The hereditary factor has not been elucidated with certainty. Voorhoeve [20] reported three cases in one family. In making roentgenograms of a fourteen-year-old boy to elicit the cause of a chronic synovitis in the knee joint he demonstrated the linear (striae) type of changes consisting of vertical streaks of increased density in the long bones of the lower extremity, pelvic bone, sacrum, calcanei, scapulae, and the ribs. Roentgenograms of the boy's sister showed the same skeletal changes. The father showed similar changes. Roentgenograms of Voorhoeve's patient have been reproduced by Sutherland [16]. Wilcox [22] observed osteopoikilosis in a father and son. Svab [17] reported the condition in a father and two sons. Bloom found an isolated lesion in a metacarpal bone of the sister of his patient. Mascherpa [9] reported "slight changes" in a brother and a sister of his patient. Hirsch [6] reported the condition in a father and son; the father showed mixed lesions, but the son showed only lesions of the nodular type.

Numerous etiological theories have been advanced: Voorhoeve thought that osteopoikilosis and dyschondroplasia might well be different manifestations of similar endochondral disturbances. Nichols and Shiflett [11] reported a patient with multiple osteochondromata, proliferative periostitis, and clinical signs of hypothyroidism and hypopituitarism, who presented the typical changes of osteopoikilosis. Wilcox [21] thought it of interest to speculate that osteopoikilosis might be associated with parathyroid disturbance. Newcomet [10], who reported the first case in the American literature, thought the areas of increased density were ostoses which grew inward. Haack [5] has expressed the theory that the changes are possibly due to small venous emboli. Tuberculosis, scleroderma, diabetes, typhoid fever, and syphilis have been reported as concomitant diseases. The simultaneous occurrence of osteopoikilosis and dermatofibrosis lenticularis disseminata, as pointed out by Curth [3], is of interest in that both conditions involve tissues of mesenchymal origin, and apparently represent manifestations of similar lesions in different organs. Stubenrauch [15] pointed out that the areas may be due either to remnants of cartilage in the epiphysis or to constricted islands of intermediary cartilage.

PATHOLOGY

Roentgenograms show two types of lesions: the nodular (spotted areas of increased density) in the spongiosa, and linear striae (streaks of condensation) along the shaft. Both types of change are illustrated in Figures 1 and 2.

Schmorl [12], whose paper was abstracted by Nichols and Shiflett, is credited with having contributed the first histopathological description of osteopoikilosis. Gross examination of cross sections of the bone in his case showed that the areas of increased density varied from needle-head to pepper-grain size. They were irregular in contour and grayish-white in color. Those in the epiphysis were almost never in the terminal lamina to which the joint cartilage is connected. Those in the diaphysis usually lay in the periphery, and rarely in the axial plane. Microscopic studies showed the areas of increased density as numerous juxtaposed trabeculae which gradually merged into the surrounding spongiosa. The thickness of the trabeculae varied; the thicker ones consisted of lamellar bone arranged mostly parallel to the long axis of the bone. Some were grouped in the periphery, concentrically around blood vessels. Schmorl did not consider an endochondral origin probable, since the areas of increased density were not connected with the endochondral zone of growth, and cartilage was not observed in the areas described. He concluded that osteopoikilosis was probably a congenital anlage.

Stubenrauch from his histological studies concluded that osteopoikilosis develops by way of endochondral ossification, and he was able to show the early formation of one of these areas of increased density on the cartilage in this manner.

Only a few patients have been observed for any length of time. Jeter and McGehee [7] reported a case in which the changes had been known

to be present for a period of fourteen years. Newcomet noted no change in the lesions during four years' observation of his patient. Nichols and Shiflett followed their case for a period of seven years without any noticeable change. This lack of roentgenographic change is in keeping with the observations of Schmorl in that he found no signs of resorption or of production in the dense areas.

The bones have no tendency to fracture and there have been no previous reports of disturbance in their epiphyseal ossification or growth. Blood calcium and phosphorus, when determined, were found to be normal.

The case herein described presents both the nodular (punctate) and the linear (striae) types of lesions, and for the first time in the history of the disease, as far as we have been able to ascertain from the literature, presents a disturbance in the epiphyseal growth as well as various contractures and deformities, the cause of which has not been determined. The patient has been observed for a period of five years. Roentgeno-

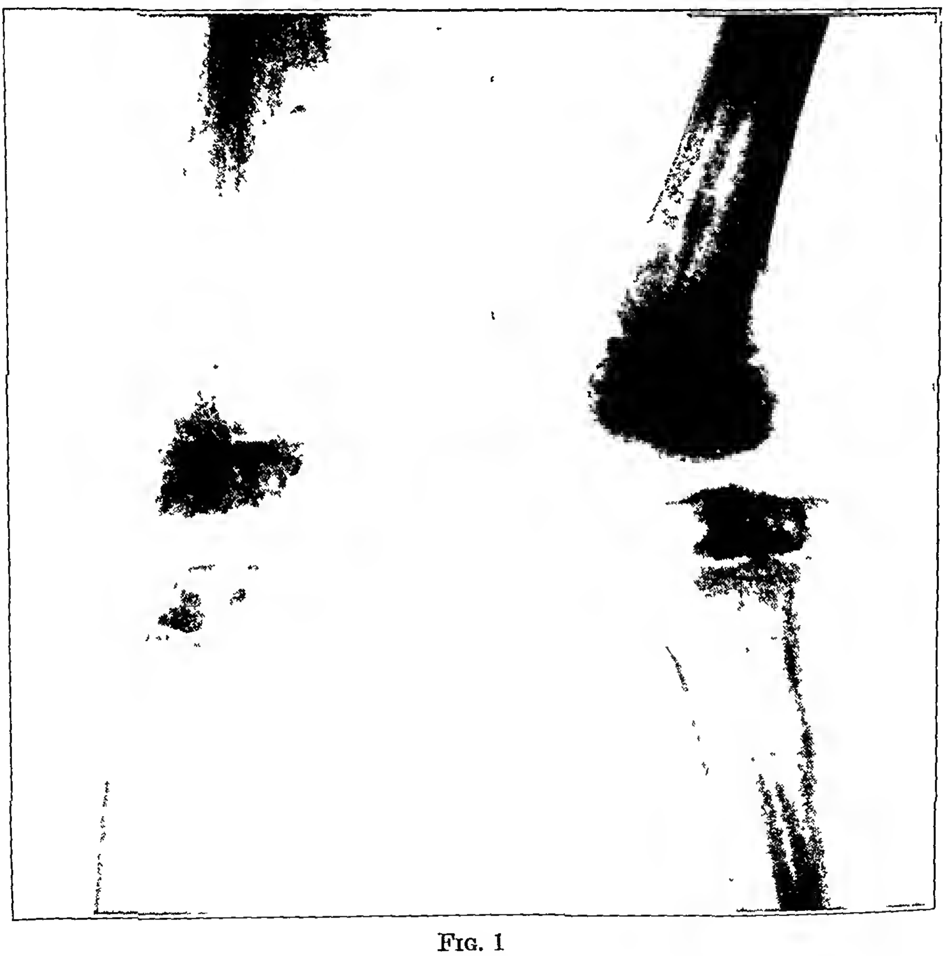

FIG. 1

Roentgenograms of the right knee. Tibial and femoral epiphyses, as well as the patella, show typical "spotted-bone" changes, whereas the diaphyses present striae areas of increased density. The enlargement of the medial aspect of the lower end of the diaphysis, and the epiphysis of the femur are not involved in the process. Roentgenograms of the left knee showed identical changes.

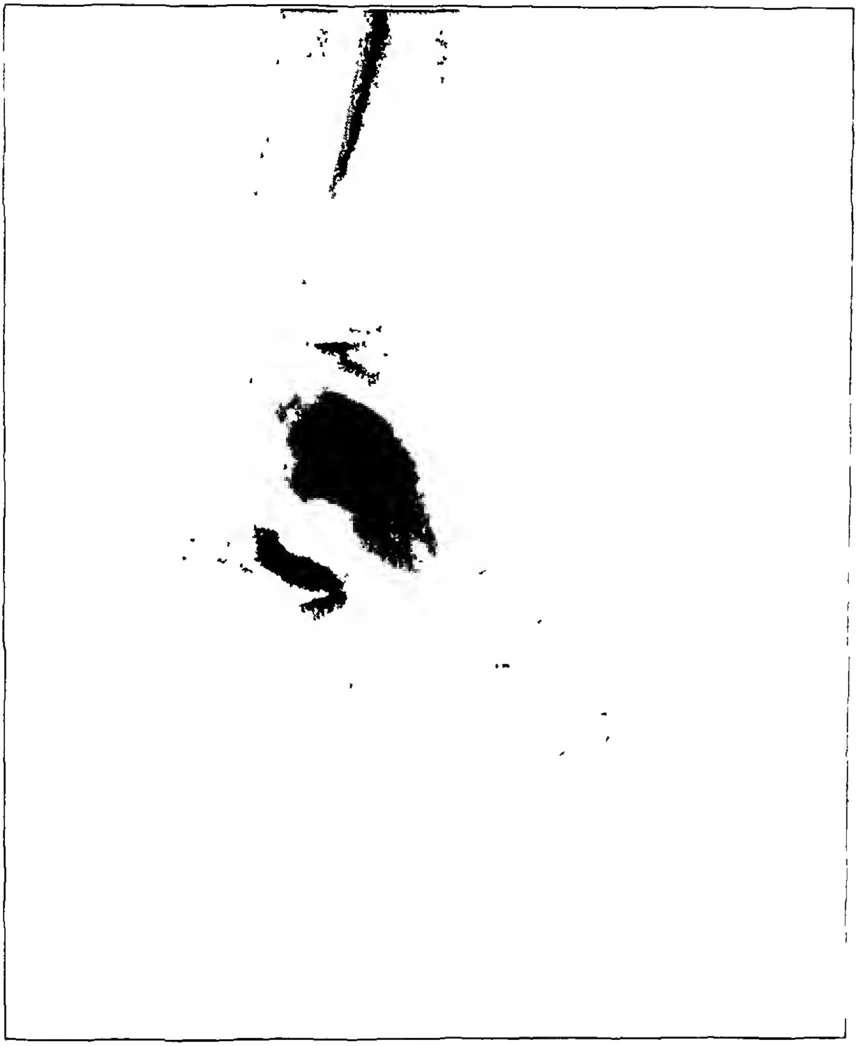

FIG. 2

Lateral roentgenogram of right foot showing involvement of the epiphysis of the fibula, all tarsal bones, proximal heads of the second, third, and fourth metatarsals, distal heads of the first, second, and third metatarsals, and proximal phalanx of the great toe. Striae changes visible in the upper two thirds of the tibia are not present in the lower third. Roentgenogram of the left foot showed similar changes in the epiphysis of the fibula, calcaneum, and cuboid, and, to a lesser extent, in the astragalus and second cuneiform.

graphic studies of other members of the family failed to show even the slightest suggestion of any osteopoikilosis.

CASE REPORT

R. F. W., an eight-year-old white male, was admitted to the Children's Hospital School on July 2, 1936, complaining of a deformity of the left foot of four years' duration, and of an asymptomatic enlargement of the medial condyle of the right femur of two years' duration.

On examination the patient stood with an equinus deformity of the left foot. The left lower extremity was adducted and the right was abducted and externally rotated. The pelvis was rotated counterclockwise and tipped forward. The spine showed a long right thoracolumbar scoliosis which disappeared when the patient was seated. The

medial condyle of the right femur presented a smooth, regular enlargement which was not tender and did not have any increased local heat or redness. There was a genu valgum deformity of the right knee with a lateral displacement of the patella, but with a normal range of motion. The right foot presented a slight varus deformity and a hallux valgus with the great toe overlapping the second toe. The proximal phalanx of the second toe was enlarged. The fourth toe showed a hammer-toe deformity. A contracted Achilles tendon held the left foot in an equinus position which could not be forcibly corrected. There was no muscular weakness and the reflexes were present.

Roentgenograms showed punctated and striated changes throughout the pelvis, the femora, pubes, the right patella, and the tarsal and metatarsal bones, as well as the phalanges of the lower extremities (Figs. 1 and 2). Roentgenograms taken elsewhere one year preceding admission showed similar changes.

The laboratory findings were as follows:

Urinalysis—negative
Hemoglobin—100 per cent.
White blood count—8,920
Blood calcium—9.7 milligrams
phosphorus—4.0 milligrams
Phosphatase—5.4 milligrams
Wassermann—negative

In a biopsy of the body of the left os calcis the bone was found to be of a normal consistency and hardness. Sections showed adult cartilage, calcified cartilage, and cancellous bone. In one area there was some variation in the thickness of the trabeculae but no increase in their contiguity. The failure of a large section of the left os calcis to show changes demonstrated in the roentgenograms was thought to be in keeping with the previously reported findings of a peripheral distribution of the areas of increased density.

Fig. 3-A Fig. 3-B Fig. 3-C

Photographs of patient. Note contractures about toes of the right foot, equinus deformity in the left ankle, and enlargement of the medial condyle of the right femur.

DISCUSSION

No definite conclusions concerning the etiology of osteopathia condensans disseminata have been reached and no new theory advanced. That it is a congenital anlage is fairly well established. The hereditary factor has not been elucidated with certainty.

The reported case is of interest in that it (1) shows both punctate and striae types of lesions, (2) has been followed for five years, and (3) presents a disturbance in the growth of one of the epiphyses as well as numerous tendon contractures and deformity.

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AN UPPER-ARM FRACTURE FRAME

BY H. K. CHRISTIE, CH.M., F.R.C.S., F.R.A.C.S.,
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From the Orthopaedic Department, Wanganui Hospital

This simple apparatus was devised in the first instance to deal with fractures above the condyles of the elbow in children. It provides both the longitudinal extension and the upward lift required to restore the short lower fragment to its correct position. It ensures the maintenance of external rotation, and it accomplishes most of the reduction automatically with a minimum of trauma to the elbow. We have been so satisfied with it that we have adopted it as one of our standard appliances.

CONSTRUCTION OF THE FRAME

Figure 1 shows the arrangement of the apparatus for a fracture of the surgical neck (adduction fracture) of the humerus. The frame itself is a simple gallows fastened to the table with brackets and screws. Anyone with a saw and screw driver can make it in a few minutes. On top of the gallows are extension pieces into which a pulley may be screwed to give the required degree of elbow flexion or extension. The table may be any small table or even the bedside cupboard. Its top is flush with the

FIG. 1

Upper-arm fracture frame showing arrangement for fracture of the surgical neck of the humerus.

mattress, which in turn rests upon fracture boards. In Figure 2 is seen a more adaptable table which fits either the left or right side of the bed. It has an adjustable upright attached, so that the line of traction may be varied to suit the fracture. The wide legs permit the x-ray tube to be swung underneath, so that the rays come up from below at an angle, while the cassette is held across the elbow flexure.

In using this apparatus for supracondylar fractures, traction is made along the surface of the table, on which the arm rests. The four hooks visible in the picture are screwed into the surface of the table, two by each bracket, as shown by the dots in Figure 2. A piece of stout calico is fastened onto the hooks, and, passing over the shaft of the humerus, holds it down on the surface of the table. This provides countertraction to the vertical weight.

When the patient is admitted to the hospital the arm is put into the frame and horizontal and vertical ten-pound weights are attached and kept in place for twenty-four hours. Traction with fine Kirschner wire is applied for a supracondylar fracture, but strapping is satisfactory for a humeral neck fracture. A few inhalations of ethyl chloride, or the injection of novocain, is required while the wire is passed through the olecranon at about the line of the humeral axis. This will clear the ulnar nerve, and the radio-ulnar joint.

The use of wire traction through the olecranon is open to criticism. The wire should be a fine one, and should be removed in three or four weeks. There is no other way of getting continuous extension—the keynote of success—in a supracondylar fracture. During the past two years there have been no complications as a result of such traction.

The elbow position at 90 degrees and the longitudinal traction which corrects the overlap are safeguards against ischaemia. When the

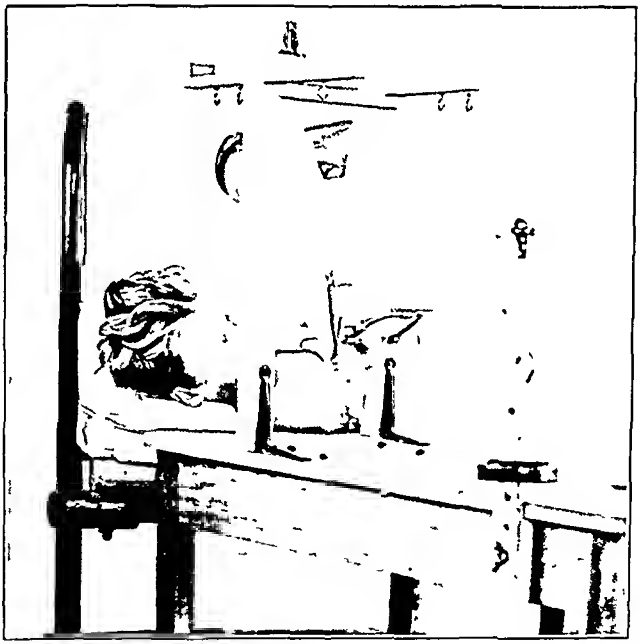

Fig. 2

Upper-arm fracture frame showing the arrangement of the table legs, permitting an x-ray tube to be swung underneath. The table fits either side of the bed. An adjustable upright carries the pulley for longitudinal extension. The hooks seen on the upper part of the frame are screwed into the table top where the dots are shown, so that the humeral shaft can be held down with a "ground-sheet" to counter the upward extension in supracondylar fractures.

roentgenogram shows no further overlap, usually the next day, manipulation under a very brief anaesthesia corrects the backward displacement. Both corrections are maintained in a child by a four-pound pull

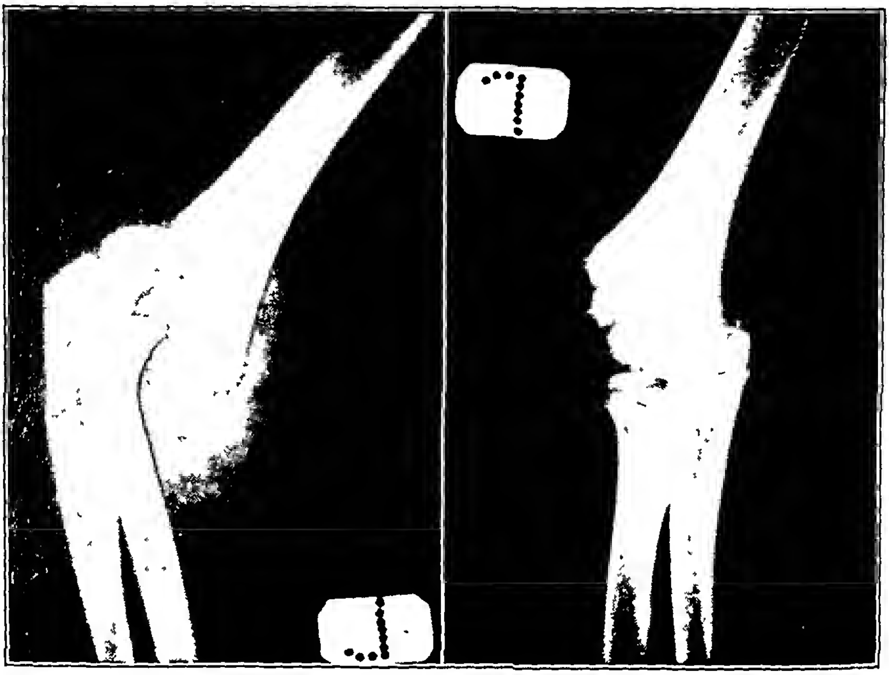

FIG. 3-A

Case 1. Fracture of the internal condyle and epicondyle.

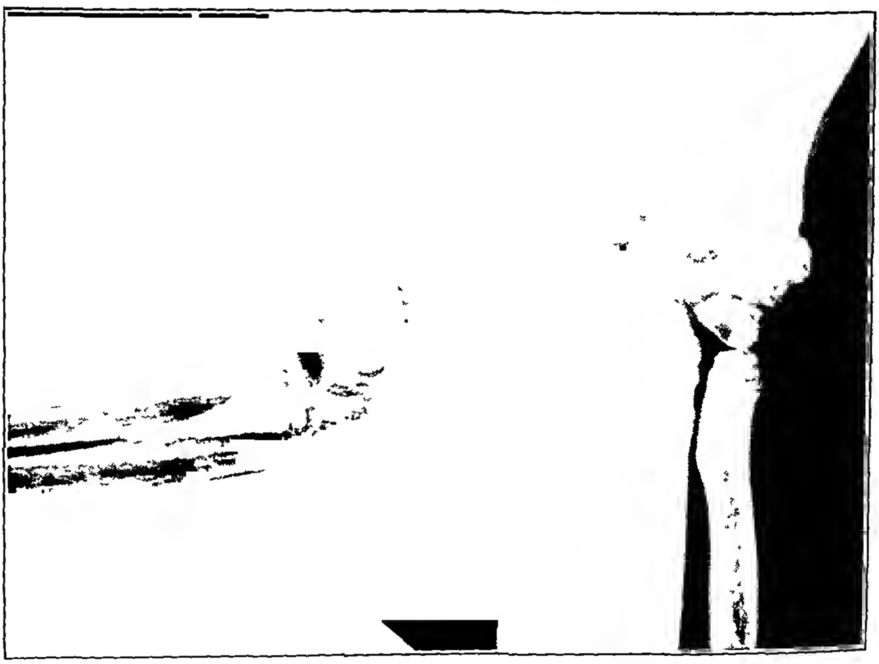

FIG. 3-B

Case 1. Two months after treatment in the frame.

over each pulley. The manipulation should be completed at one time, as subsequent manipulations spread the haematoma and promote excess callus. The rapid formation of callus in children may preclude a reduction by the end of ten days.

FIG. 4-A

Case 2. Supracondylar fracture of the humerus.

FIG. 4-B

Case 2. After treatment in the frame for four and one-half weeks.

FIG. 5-A

Case 3. Adduction fracture of the neck of the humerus.

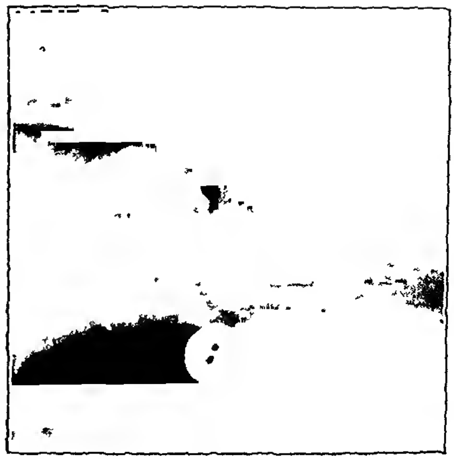

FIG. 5-B

Case 3. Six weeks after treatment in the frame in abduction of 90 degrees.

After three weeks, extension is discontinued, the arm placed in a sling, and active movements and massage commenced.

A few roentgenograms are reproduced to show some humeral fractures reduced in this very sure and convenient apparatus (Figs. 3-A, 3-B, 4-A, and 4-B).

Almost all humeral fractures may be treated in the frame, except impacted abduction fracture of the humeral neck in adults. These should be treated in adduction.

Although especially designed for children, a slightly larger frame is suitable for adults. A plaster strip may be used in addition for a shaft fracture.

The dislocated shoulder combined with a fracture of the tuberosity or avulsion of the supraspinatus, is especially suitable for treatment by the frame. After reduction of the dislocation, traction in abduction of 90 degrees restores the torn capsule as well as reduces the separated tuberosity.

ADVANTAGES OF THE UPPER-ARM FRAME

1. *Simplicity.* It can be constructed by anyone and used in the patient's own home.

2. *Control.* Any desired degree of abduction, external rotation, and flexion at the shoulder, and of flexion or extension at the elbow can be maintained.

3. *Facility.* Manipulation can be carried out in the frame, with the help of its traction. Roentgenograms can be taken from the side or from below. Plaster strips may be applied at any stage with no risk of redisplacement.

4. *Convenience.* It guards against ischaemia, saves time, and reduces manual manipulation to a minimum.

5. *Comfort.* The patient is at once both relieved of his pain, and put under complete control.

TREATMENT OF ACUTE ACROMIOCLAVICULAR DISLOCATION

BY VERNON L. HART, M.D., MINNEAPOLIS, MINNESOTA

Complete acute traumatic separation of the acromioclavicular joint is a serious and not uncommon injury. A fall or blow on the prominence of the shoulder results in a rupture of the acromioclavicular and coracoclavicular ligaments. There is a downward displacement of the acromion and an upward displacement of the clavicle. The deformity can be reduced by pushing upward on the elbow while pressure is applied downward over the lateral portion of the clavicle. The deformity recurs as soon as the pressure is released because stability of the joint depends entirely upon ligaments and not upon anatomical configuration of the two bones. Proper treatment demands complete reduction of the dislocation and uninterrupted maintenance of the reduction until the ligaments have

FIG. 1

Plaster-of-Paris shoulder spica with adjustable padded webbing straps and buckles, for treatment of complete acute traumatic acromioclavicular dislocation.

FIG. 2

Plaster-of-Paris shoulder spica with upper half removed.

healed. Adhesive dressings are uncomfortable and inefficient and too frequently permit an acute dislocation to become a chronic one which requires surgical correction.

During a period of ten years the writer has used a method of treatment (Fig. 1) which has proved to be comfortable and efficient. A plaster-of-Paris shoulder spica is applied while the scapula is elevated with the arm in a position of about 45 degrees of abduction. The plaster spica

anchors the elevated acromion. Downward pressure can then be applied over the lateral portion of the clavicle by means of two two-inch webbing straps with buckles which are incorporated within the plaster spica during its application. The continuous pressure over the clavicle is made more comfortable by placing a layer of felt and a firm rubber sponge between the webbing straps and the skin over the clavicle. This arrangement of cast and adjustable padded webbing straps fulfills the requirements of treatment, which are continuous and uninterrupted reduction of the dislocation, with comfort, until the ligaments have healed. A period of six to eight weeks is required for healing of the ligaments.

After the cast has been applied a window about one and one-half inches in diameter should always be removed from the cast at the elbow to prevent pressure necrosis of the skin over the internal epicondyle, and pressure neuritis of the ulnar nerve.

After the fourth week of treatment, the upper or cephalad half of the plaster which encases the extremity is removed (Fig. 2). The patient is instructed to use actively all motions of the elbow joint, and abduction and external rotation of the shoulder. The complete range of elbow and shoulder motions will then have been restored when the entire cast is removed at the end of six to eight weeks.

CORACOCLAVICULAR ARTICULATIONS

BY P. DAVID NUTTER, M.D., HUNTINGTON, WEST VIRGINIA

From the Bone and Joint Service, Receiving Hospital, Detroit, Michigan

Contrary to the belief expressed in the works of most authors on coracoclavicular articulations, these joints are not rare conditions.

The author's attention was first called to the existence of these joints by Gradoyevitch's article describing the x-ray findings of a case with evidence of bilateral coracoclavicular joints. In this report, he stated that prior to the discovery of his case only fifteen other cases were known to medical science, ten of which had been proved anatomically and five roentgenographically.

The purpose of this article is to give a roentgenographic description of this joint and to present evidence of the frequency of its occurrence. The discussion and findings relative to the anomaly as presented by other authors will not be repeated here, since this was adequately coveied in Gradoyevitch's work.

Absolute proof of the existence of this joint, as Gradoyevitch states, "demands evidence of two cartilaginous articular surfaces,—a capsule and a synovial membrane", the essential anatomical structures of all *true joints. Although all these separate anatomical structures cannot* be demonstrated by ordinary roentgenographic methods, the presence of a large clavicular bony process, which has a facet that conforms to the adjacent end of the coracoid, appears to be as adaptable to this surface

Fig. 1

Case 6. Roentgenogram of chest showing the presence of bilateral coracoclavicular articulations.

Fig. 2

Case 8. Roentgenogram of left shoulder showing the presence of a typical coracoclavicular articulation.

as the surfaces of other true joints are adaptable to each other, and with the coracoid forms an interarticular space, leaves little doubt that the other joint structures are also present.

These articular bony outgrowths on the clavicle are present at the site of the tuberosity for the attachment of the conoid ligament. Often in an adult clavicle this tuberosity can easily be defined roentgenographically. Sometimes this tuberosity is as large as the apophysis of a coracoclavicular joint, but it does not possess the same smooth, concave articular facet. In some cases no conoid tuberosity can be demonstrated by roentgenograms; the outline of the bone at this point is smooth and continuous with the general outline of the inferior surface of the clavicle.

Of 1000 unselected roentgenograms of adult shoulders taken for various conditions at Receiving Hospital, twelve roentgenograms, or 1.2 per cent., gave evidence of coracoclavicular joints. Of these twelve patients with coracoclavicular joints the condition was bilateral in six. In only two of the other cases were roentgenograms taken of both shoulders.

This condition was present in eleven male patients and one female. Unfortunately a record of sex was not kept in the original 1000 cases; therefore, this does not give an accurate sex distribution of this condition.

Five cases had roentgenograms of the chest for suspected lung pathology. Three of these gave roentgenographic evidence of bilateral symmetrical apophyses, with facets adaptable to each corresponding coracoid process. In one case, all of the left shoulder was not included on the plate, and in the remaining one an articular process was present on the left clavicle, but on the right there was only a tuberosity for attachment of the coracoid ligament. This did not possess the smooth, concave surface similar to that of the left side.

In four cases roentgenograms were taken of the shoulders. Three of these patients had suffered recent injury, and one (Fig. 2) complained

of pain over the subacromial bursa. Only one patient in this group had an x-ray taken of both shoulders. This revealed evidence of a coracoclavicular joint on the left. On the right, the conoid tuberosity was prominent, but its inferior surface was rounded and did not possess an articular facet. Examination of both shoulders showed them to be symmetrical with normal motion.

Only three patients in the entire series had detailed physical examinations for evidence of presence of coracoclavicular joints. In these no abnormality was demonstrated that could be attributed to their presence.

From this study it can be concluded that the anatomical and physiological significance of these joints is only academic. However, inasmuch as they are true joints, it can be presumed that they are not exempt from any of the various pathological conditions which affect any other joint.

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A UNIVERSAL SPLINT FOR EMERGENCY IMMOBILIZATION OF FRACTURES OF THE EXTREMITIES, NECK, AND BACK

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From the Section of Orthopaedic Surgery, Yale University

The splint described here has a variety of uses in the emergency immobilization of fractures and has been successfully used in our clinic as part of the ambulance equipment. It is a stable and simple mechanism for the immobilization of an extremity, neck, back, or pelvis. Additional advantages are that the mechanical adjustments are not complicated, the apparatus can be applied quickly and easily, and can be collapsed to an over-all length of thirty-three inches for storage (Fig. 4). It occupies considerably less space than some of the other conventional splints. Because of its compactness it can be carried in a suitcase as equipment for emergency care of athletic teams. Fitted into a flat canvas case, which also contains bandages and first-aid dressings, it can be carried in the physician's car, or made available as emergency equipment in first-aid stations and public vehicles, such as buses and trains, etc.

For adequate immobilization the standard emergency splint equipment must include at least two of the customarily used splints to be suited to the diameter and length of the upper and lower extremities in

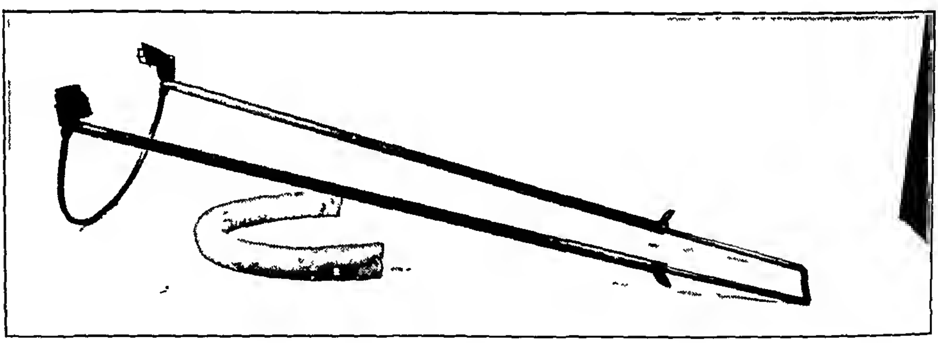


Fig. 1

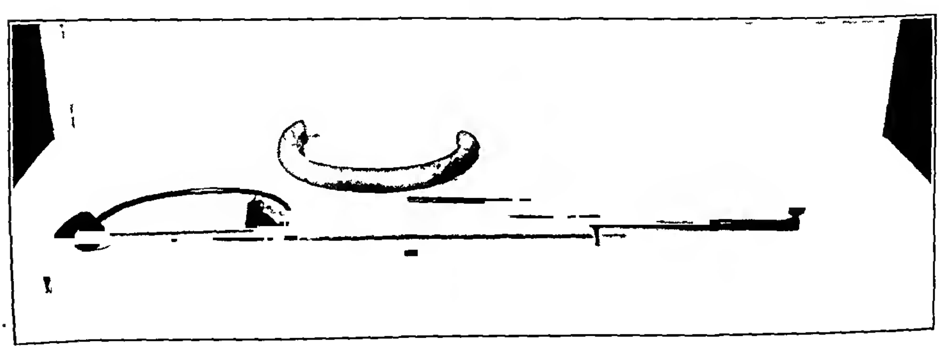


Fig. 2

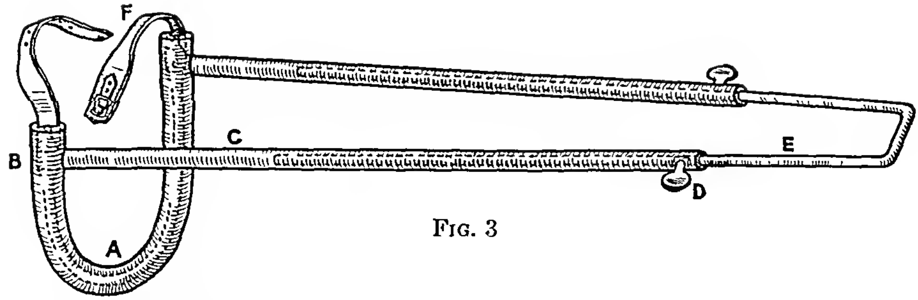


Fig. 3

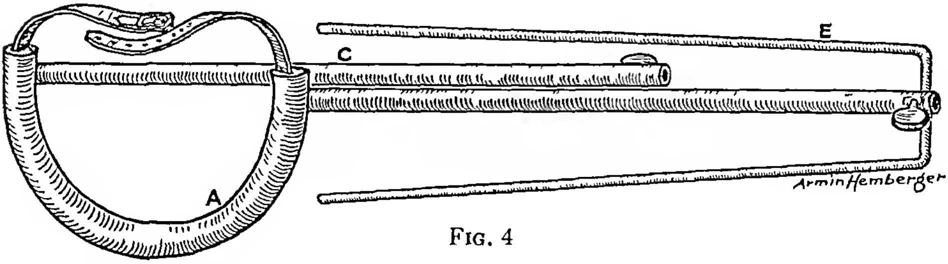


Fig. 4

adults and children. This universal splint is interchangeable for either the upper or lower extremities and is also adjustable to their length and diameter.

The splint is composed of two major parts. One part consists of a half ring (*A*), nine and one-half inches between the free ends and seven inches in depth, at the ends of which are attached two tubular rods (*C*). These rods, which are twenty-four inches in length and 0.33 inches in diameter with an 0.26 inch bore, form the side arms of the splint and are joined to the ring by means of two right-angled joints (*B*). A strap (*F*) joins the free ends of the half ring which may be covered with either leather or rubber from a baby-buggy tire. The second part consists of a U-shaped rod (*E*), with arms twenty-two inches long and 0.24 inches thick, which fit easily into the tubular side arms of the splint. The base of the U-shaped rod is five inches in width. The position of the rod within the tube is maintained by means of thumb screws (*D*).

The width of the splint can be adjusted, by altering the angles between the ring and the side arms, from approximately five inches (Fig. 5) to nine inches (Fig. 6),

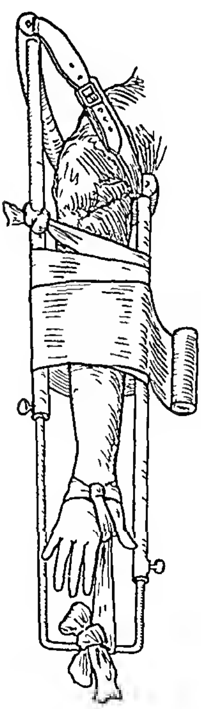


Fig. 5

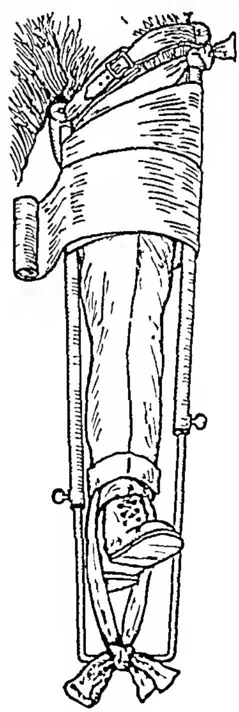


Fig. 6

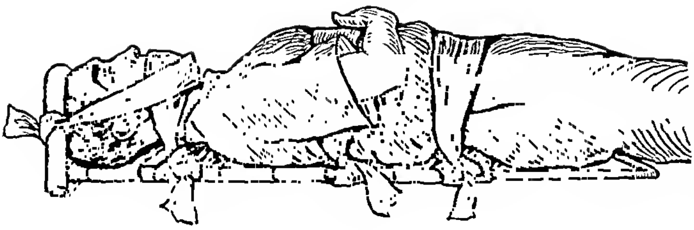


FIG. 7

and, as it can thus accommodate variations in the diameter as well as the length of the extremity, it is applicable for use with children and adults.

When used for the immobilization of the head, neck, and back, and for injuries to the pelvis, the half ring is maintained at right angles to the side arms of the splint, and the length of the splint is adjusted to extend just beyond the level of the greater trochanters (Fig. 7). The thumb screws are set so that they remain flat. The splint is passed beneath the individual, and the head, neck, and trunk are held in place by means of bandages. Such immobilization provides adequate stability and protection during transportation of the patient.

Because of its adjustability the splint may also be used in the bed care of fractures requiring traction-suspension treatment.

A SIMPLE CORRECTIVE DEVICE FOR HALLUX VALGUS

BY MARTIN BATTS, JR., M.D., GRAND RAPIDS, MICHIGAN

A simple, efficient, inexpensive, and comfortable corrective device for hallux valgus is difficult to find. The device herewith illustrated meets all these requirements. Its action is similar to that of the stretched

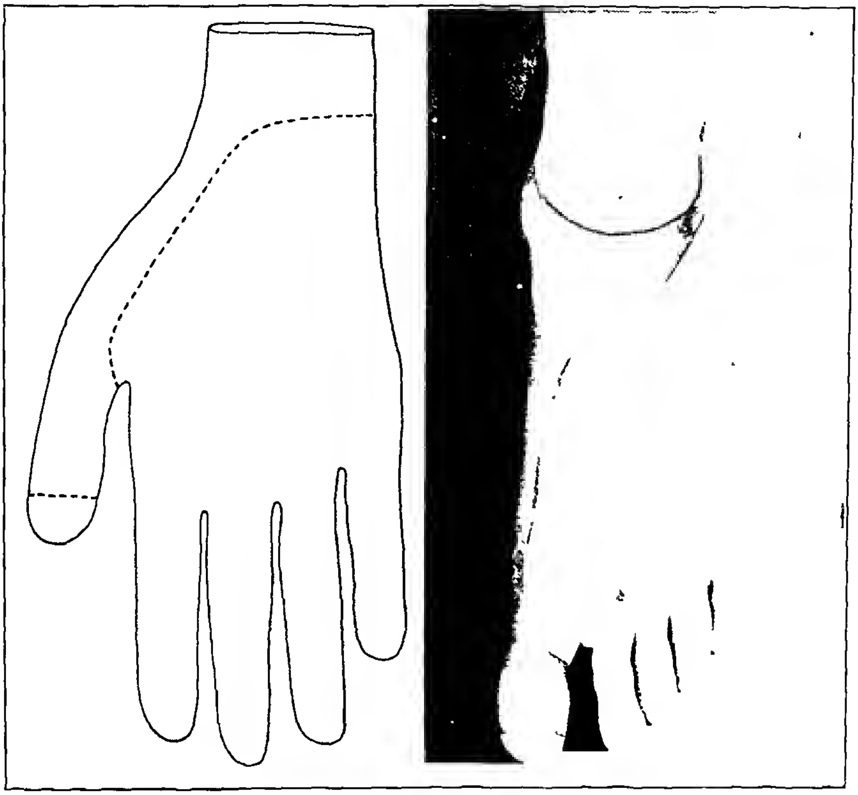


Fig. 1

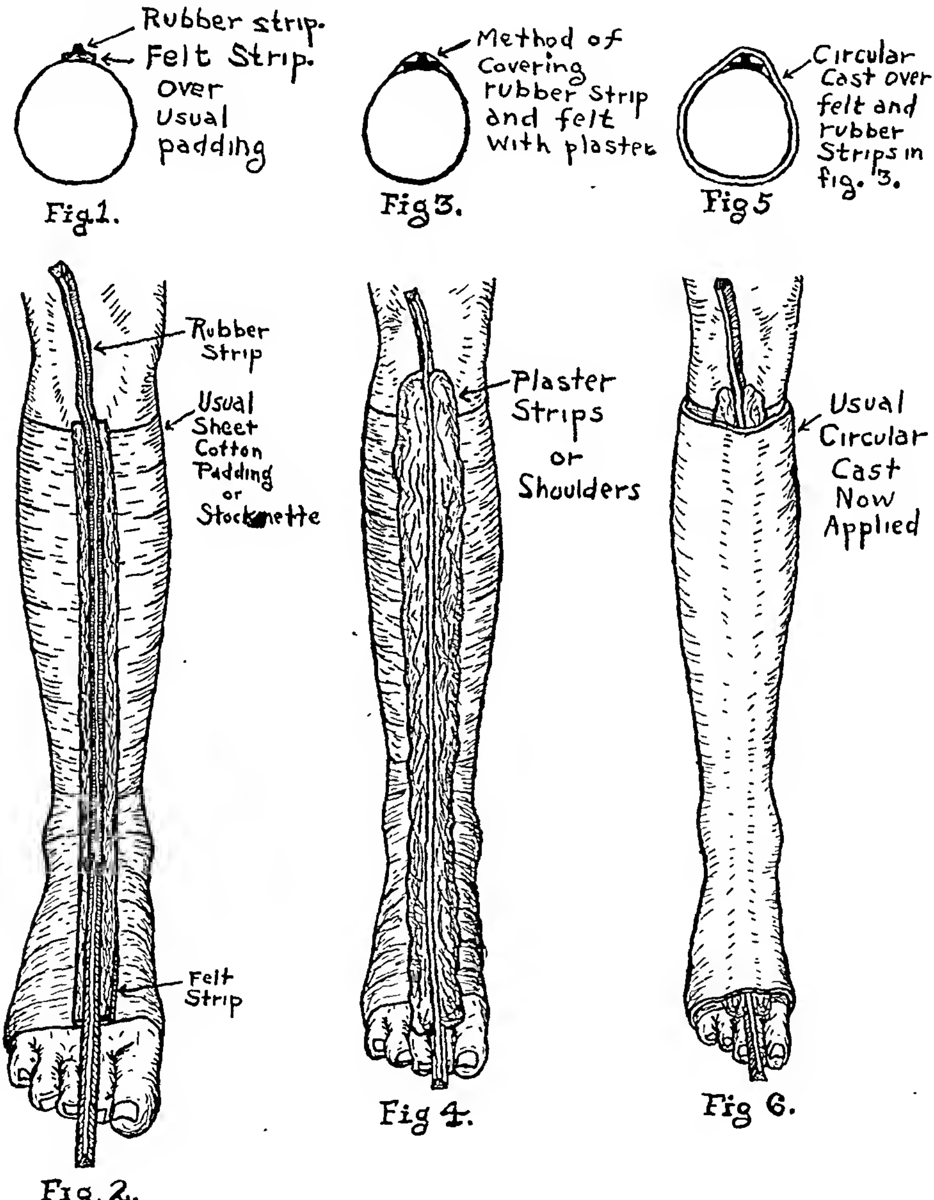
and non-functioning abductor hallucis. A rubber glove is cut in the manner indicated in Figure 1, and the appliance is immediately ready for wear. It has been found to be especially useful in maintaining a post-operative correction of a hallux valgus.

A SIMPLE METHOD OF APPLYING PLASTER CASTS TO PROVIDE FOR EASY REMOVAL

BY WILLIAM J. WILSON, M.D., NEW YORK, N. Y.

From the New York City Hospital, Welfare Island, New York

Because of the difficulty encountered in removing snugly fitting plaster casts, the following method of application has been devised. Casts applied in this manner are as comfortable as the usual circular cast and



Method of Applying Cast

retain all of its advantages. For the sake of clarity the description will be for a toe-to-knee cast, as shown in the accompanying illustrations. However, this same principle may be applied to other casts.

An ordinary rubber automobile fan belt may be secured from any automobile supply or hardware store. The loop is cut so that the fan belt becomes a long strip, a cross-section of which is shown in Figure 11. The strip is rubbed with paraffin to prevent its sticking to the cast when used.

The foot and leg are first enclosed in stockinette or wrapped with sheet cotton. A strip of piano felt two inches wide and long enough to extend entirely through the cast is laid along the anterior surface of the foot and leg. On top of this the rubber strip is laid, with its widest surface in contact with the felt (Figs. 1 and 2). Two strips of plaster bandage are

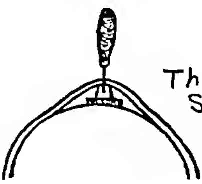


Fig. 7.

Fig. 9.

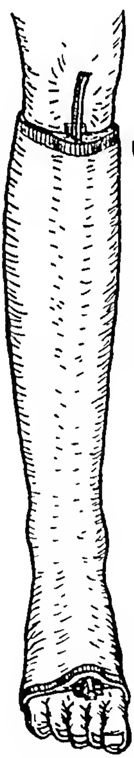


Fig. 8.

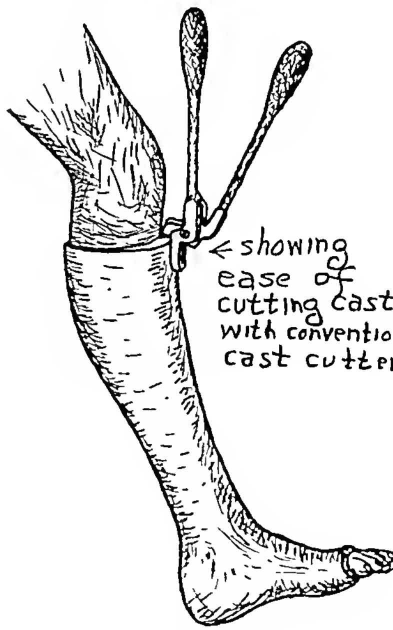


Fig. 10

Fig. 11.

placed on either side of the rubber strip, covering the felt strip, to restore a smooth rounded contour (Figs. 3 and 4). Over this a circular cast is applied in the usual manner (Figs. 5 and 6). The cast is trimmed and finished as desired (Fig. 8), and the rubber strip pulled out as soon as the plaster has set, but while it is still wet. One hand placed over the instep while the strip is pulled with the other eliminates any danger of breaking the cast.

The finished cast is a circular one with a grooved inner surface extending through it. The margins of the groove are amply padded and cause no discomfort whatsoever to the patient. This cast is easily removed as the groove readily admits the lower jaw of a conventional cast cutter, as shown in Figure 10. The cast is then opened with a cast spreader and removed.

This method of application also provides a safe method of splitting and spreading a portion of the cast when unexpected or postoperative swelling of the part occurs (Fig. 7). The underlying groove keeps the knife or saw from contact with the skin.

Certain modifications of this method can be made to suit the individual, such as substitution of two or three thicknesses of narrow sheet cotton for the felt. This is adequate in cases where weight is not borne on the part, but with walking iron casts the felt strip should be used or the rubber strip left in. In walking iron casts, this method of application is especially useful as the extra plaster necessary to fix the walking iron usually makes the cast more difficult to remove, but in this type of cast all the plaster is easily cut at the same time.

This method has been used on quite a few patients at the New York City Hospital with very satisfactory results. Only a few minutes more are required for application and the extra time is amply repaid by the ease and rapidity with which the cast is removed. A walking iron cast of this type has been removed in a little less than three minutes.

The cast retains all the strength of a conventional circular cast. It has the advantage of greater strength and more complete immobilization than casts routinely split over a tin strip, without the danger of having the knife leave the tin strip and cut the patient. The rubber strip, which is removed each time, may be used in the application of any number of casts.

VITTORIO PUTTI

March 1, 1880—November 1, 1940

Vittorio Putti was Professor in the University of Bologna, Surgeon-in-Chief of the Istituto Ortopedico Rizzoli, a founder of the Société Internationale de Chirurgie Orthopédique et Traumatologie and President of its 1936 Congress, Honorary Member of the British Orthopaedic Association, the American Orthopaedic Association, Corresponding Member of the American Academy of Orthopaedic Surgeons, and many other national organizations. He was a bibliographer, medical historian, orthopaedic investigator, and teacher of surgeons. He had been a Foreign Editor of *The Journal of Bone and Joint Surgery* since January 1928.

Bologna was a Roman city. The Cathedral of San Pietro e San Paolo, built in part from the Roman remains, was erected in the fourth century. The city has long been a seat of learning, and legends attribute the founding of the famous University of Bologna to Theodosius the Great in 425 A. D. Among the students of this University were Dante (1265–1321), Petrarch (1304–1374), and Luigi Galvani (1737–1798), the discoverer of galvinism. One of the most famous professors was the anatomist Marcello Malpighi (1628–1694). In 1262 the students of the University were said to number nearly 10,000. The student population has decreased, but the Medical School of the University is still outstanding.

The Istituto Ortopedico Rizzoli is situated on a hill on the outskirts of this fascinating old city and occupies the picturesque buildings of a Benedictine Monastery known as San Michele in Bosco. The early years of this institute for crippled children were not noteworthy, until Alessandro Codivilla, modest and skillful master, became its Director and Surgeon-in-Chief. This great general surgeon, after excelling in the surgery of the gastro-intestinal tract and the brain, devoted his talents to orthopaedic surgery, and the "Istituto" became world-famous. Codivilla made original and important contributions to the surgery of fractures and the methods of tendon transplantation, and to the development and standing of the specialty.

At his death in 1912 Codivilla was succeeded by Vittorio Putti, the son of a well-known surgeon who was for many years Professor of Surgery in the University of Bologna. Putti had first become identified with the Istituto Ortopedico Rizzoli in 1903 when Codivilla had appointed him as an assistant. Following two years of study in European clinics, he returned to the institution in 1909 as Vice-Director, and in 1914 became Director and Surgeon-in-Chief of the Istituto. He was also Professor of Orthopaedic Surgery at the University of Bologna.

In 1922 he opened the country branch which provided for the care of 100 cases of surgical tuberculosis, and as Director of this hospital (Istituto dio terapico Codivilla di Cortina d'Ampezzo) in the Dolomites he found frequent escape from his overstrenuous city life.

A brilliant student, a wide reader, an able administrator, a resourceful and skillful surgeon with a mechanical bent, he enhanced the reputation of the Istituto Rizzoli, and like Codivilla, made lasting contributions to the history of medicine and to the technique of orthopaedic surgery.

In addition to being a tireless and exacting trainer of young surgeons, he encouraged his associates to become familiar with the history of medicine and the contributory sciences, to strive for exactitude in thought and action, and to appreciate beauty not only of art and nature but of character. His sanctum sanctorum, which he shared with his helpers, was the library (La Biblioteca Umberto I). On the walls of this dignified room are the same beautiful frescoes, executed by Canuti, that had given joy to the monks, and on its shelves are books and manuscripts covering a period of over 400 years.

VITTORIO PUTTI

By his numerous original contributions he became an international leader, a pioneer and an authority on bone and joint surgery, especially on congenital dislocation of the hip, its preluxation stage and its automatic reduction by the *divaricatore,* arthritis, arthroplasty, "sciatica", the forcible manipulation of adult club feet, the open treatment of fractures and the use of skeletal traction and metal fixation, the equalization of leg lengths by bone lengthening, spinal anomalies, cineplastic amputations and artificial limbs, and the surgical treatment of the residual effects of poliomyelitis. He published many monographs, not only on strictly medical and surgical subjects, but also on non-medical subjects, as well as translations of old medical works. His large quarto, "Berengario da Carpi" published in 1937, represents not only a profound and extensive piece of research, but the best biographical study of this great surgeon and anatomist who antedates Vesalius. This work alone places him among the great medical historians. His latest volume, published in 1940, is entitled "Cura operatoria delle fratture del collo del femore".

He was active in organizing *La Chirurgia degli Organi di Movimento* which was first

published in 1917. He continued as the editor of this outstanding medical journal until his death.

He was an accomplished linguist and lectured by invitation in practically every country, including the United States, England, France, Germany, and Russia. He visited England and America often and loved them both. He was a guest of the American Orthopaedic Association at its Boston Meeting in 1921, and delivered later the Lane Lectures in California. He was the guest speaker at the Congress of the American College of Surgeons held in Boston in 1934 and in Chicago in 1937.

His titles were too numerous to mention for he was a corresponding, honorary, or active member of most of the orthopaedic societies of the world. His honors included civilian, medical, surgical, military, and academic recognition. He received from the King the title of Grand Officiali of the Crown of Italy.

Putti enjoyed the friendship of a host of physicians and surgeons throughout the world and was an inspiration to them. Those who knew him well discovered a depth of feeling and a capacity for friendship which were the true attributes of his character. After the death of his professional ideal, Sir Robert Jones, he wrote the following letter in English to an American colleague. Its exquisite diction suggests a faith and an affection which are almost religious in nature.

"Dear ———

The death of our unforgettable Sir Robert has made me think a great deal about you in these days. It is a great friend who has left us, and I think that all of us who loved him feel the need of uniting together in his memory.

Let our friendship find in his memory strength of faith and reason of comfort.

Do not forget me and believe me

Affectionately yours,

PUTTI"

Vittorio Putti will rank among the great orthopaedic surgeons of all time—great in heart as well as in mind and hand.

REGINALD CHEYNE ELMSLIE

1878–1940

The death of Reginald Cheyne Elmslie, on July 24, 1940, at the age of sixty-two years, has robbed British orthopaedic surgery of one of its stoutest champions. The son of Captain J. A. Elmslie, R.N.R., he was, through his great-grandfather, Dr. John Cheyne, descended from three successive John Cheynes, all of whom practised surgery in Edinburgh.

At the age of seventeen, Elmslie entered St. Bartholomew's Hospital where he obtained a number of scholarships and qualified with the Conjoint diploma in 1901. In 1904 he was awarded the Gold Medal in the examination for the Mastership of Surgery and also became a Fellow of the Royal College of Surgeons. In the following year, when he was awarded the Jacksonian prize of the College for his essay on "The Pathology and Treatment of Deformities of the Long Bones due to Disease occurring during and after Adolescence", it was already clear in which direction his tastes lay. Then came a number of increasingly responsible appointments, but one of them, generally regarded as nothing more than a stepping-stone, left a permanent mark on his intellect. For five years Elmslie held a demonstratorship of pathology at St. Bartholomew's Hospital; and in later life he never lost his interest in the pathology of crippling conditions, to which subject he made a number of valuable contributions.

He was the first man in England seriously to apply clinical pathology to orthopaedics and one of the few orthopaedic surgeons who regarded a microscope as an essential part of his equipment. He was appointed to the staffs of the Metropolitan Hospital and the Royal National Orthopaedic Hospital. In 1912, he became Surgeon-in-Charge of the Orthopaedic Department at St. Bartholomew's Hospital, where he was the first member of the staff to devote himself exclusively to the practice of orthopaedic surgery. It was no easy task for him to build up a department in a hospital as conservative as it was venerable—indeed it was not until he had been there for many years that he obtained an operating theatre of his own—and he was never given satisfactory accommodations for in-patients or for a massage department. However, patients came to the new department in numbers, and his teaching quickly attracted many eager pupils. As surgeon to the Orthopaedic Hospital he spared no effort to bring about the transition from the "brace-and-tenotomy" orthopaedics of the last century to the comprehensive science into which this great branch of medicine has now grown.

A catalog of Elmslie's many other offices is a necessary preliminary to an appreciation of his character. In 1905 he was appointed the first inspector of crippled children in the enormous area controlled by the London County Council; he was a pioneer in this invaluable preventive and therapeutic work. After the war of 1914–1918 he presented a comprehensive and scholarly report, at that time unique, on the prevention and treatment of crippling diseases in children, which ultimately formed the basis for the legislative reforms that led to the establishment of orthopaedic schemes throughout the country. He was one of the founders and a most active member of the Central Council for the Care of Cripples, and in 1938 became Chairman of its Executive Committee. At the Fourth World Conference of Workers for Cripples held in London in July 1939, he read a remarkable paper, showing how the organization of orthopaedic work had led slowly but surely to a striking decrease in the incidence of severe crippling in Great Britain. Elmslie was instrumental in obtaining the Charter for the Society of Massage and Medical Gymnastics, of which he was Chairman from 1929 to 1935. During the last war he was chiefly responsible for making the Military Orthopaedic Hospital at Shepherds' Bush into a world-famous center for the treatment of war injuries; he was also surgeon to the Pensions' Hospital at Roehampton, and was later appointed Consulting Surgeon to the Ministry of Pensions. He served as the only medical member of the Royal Commission on

REGINALD CHEYNE ELMSLIE

Workmen's Compensation. Elmslie was one of the little band that gathered around Sir Robert Jones when the British Orthopaedic Association was founded, and in due course he was elected President. From 1933 until his death he served on the Council of the Royal College of Surgeons, an honor accorded to few orthopaedic surgeons.

This list, from which several important appointments have been omitted, serves to show the remarkable range of the man's interests,—they were the interests of a scholar with an active and receptive mind and an unusual capacity for analyzing all that wide experience and unceasing study had stored in an exceptionally retentive memory. Elmslie might justly be called an authority; his judgment was superb and his opinions almost invariably sound. In the course of one busy morning he has been known to discuss a wide variety of subjects, each topic neatly summarized, old ideas presented in a new light, with every observation revealing how carefully he had thought over the problem.

Yet he was not dogmatic. When dealing with colleagues or an opponent in debate he could be, and often was, devastatingly direct and uncompromising; but with any man who showed keen interest in a subject or brought out something new, he was instantly sympathetic and ready to listen, and generous in his acknowledgment of whatever was good.

Few British surgeons since Lister have founded schools in the sense of leaving after them a considerable body of disciples of their own training. In the orthopaedic world there have been two notable exceptions, Robert Jones and Elmslie. An astonishing number of his pupils are now orthopaedic surgeons, and the influence of his teaching has permeated nearly every center in the south of England. He was at his best when teaching in "out-patients at Bart's". He would select a few cases for demonstration, sometimes new patients, and examine each methodically and quickly. When a diagnosis had been made he would offer a neat exposition of the condition and perhaps a few words about its treatment, illustrated by little drawings on the blackboard. It was the simplicity of this teaching that made the subject so attractive and stripped it of that aura of mystery that for too long had marked orthopaedic surgery as something beyond the ken of the undergraduate. The same simplicity characterized Elmslie's operating. He knew what he was doing, and what was even more important, he knew why he was doing it. The facility and gentleness that marked his work gave an impression of ease that was deceptive.

As a pioneer, Elmslie was known best perhaps to those concerned with the social aspect of orthopaedic surgery and massage. On the purely surgical side his vision was too wide and his poise too balanced for the pursuit of pet enthusiasms—he saw too many panaceas die in infancy—and he scorned fashions and novelties in his specialty. Nevertheless he substantially advanced the subject by a number of valuable original contributions; he unravelled the varieties of coxa vara at a time when hardly anything was known about this deformity; he brought order out of the pathological chaos that went by the name of fibrocystic disease of bone. In many other conditions he was especially interested, and yet his numerous writings hardly do him justice because they were in no way commensurate with his knowledge. Several excellent operations bear his name, but only among those who knew him for he never published descriptions of them.

At this close range Elmslie's character is a little difficult to assess. The accompanying photograph, a good one taken late in life, suggests an aloofness that might be almost forbidding. Aloof he was; he lived simply; he loved his work; he cared nothing for popularity, and he scorned publicity. He was warm in his friendship, a friendship enjoyed by an ever-widening circle of colleagues and disciples. His conversation ranged over a host of topics and rarely ended without a little story which always began with "I'll tell you something . . ." and never contained a sting. Elmslie was transparently honest; his opinion was uninfluenced by personal considerations; his views about public affairs in relation to orthopaedic surgery were dictated by one ultimate aim—the prevention and the relief of crippling. His advice to a younger man was based solely on what he thought best for him in relation to his ability and his circumstances. This solid reliability, known only to those who took the trouble to discover it, was his greatest quality, and his friends feel acutely the loss of a man whose rectitude was warmed by a kindly humanity that inspired loyalty and affection in those who worked with him.

It was inevitable that a surgeon so passionately devoted to the advancement of orthopaedic surgery, particularly in its institutional and social aspects, should meet with many disappointments. Some of his plans, well and truly laid, never matured, or did so only after almost endless setbacks, and yet he never became cynical. Even when ill health made the day's work increasingly burdensome, he continued his way patiently without neglecting any task to which he had set his hand. Had it not been for his increasing weakness of body, he would have played a decisive part in the reorganization of medical services so urgently demanded by the war. To be barred from this was perhaps his greatest disappointment, for he was above all things anxious to serve his country.

LETTER TO THE EDITOR

NOTE: The growth of a new department of medicine or surgery does not take place according to regular methods of expansion, but is often determined by the influence of personal contacts and centered about the efforts of individuals located in various sections of the country. This results in an irregular distribution which is not recognized until a study of the situation is made. Such a survey indicates the geographical needs for further development of equipment and particularly of personnel. This report is given for those who may have special use for this information.—*The Editor.*

To the Editor:

For a long time I have thought that residents finishing their formal course in orthopaedic surgery should have some guidance in the selection of a place to practice their profession. I am, therefore, submitting some ideas which you may see fit to publish in *The Journal of Bone and Joint Surgery.*

How many people are necessary to support an orthopaedic surgeon in the United States?

The Secretary of the American Board of Orthopaedic Surgery estimates that they have certified about half the orthopaedic surgeons, which would give an estimated total of 1200 orthopaedic surgeons. So then in continental United States (census of 1940) there would be one orthopaedic surgeon to every 110,000 people.

How are these specialists distributed among the states?

Below are the states arranged according to persons per orthopaedic surgeon (000 omitted).

District of Columbia	47	North Dakota	106	Iowa	180
Maryland	56	*General Average*	*110*	Hawaii	184
Washington	57	Wisconsin	111	Florida	187
New York	63	Illinois	115	Indiana	190
Delaware	66	Rhode Island	118	South Carolina	190
California	67	Virginia	120	Maine	210
Nebraska	73	Tennessee	121	Kansas	225
Massachusetts	74	Arizona	124	New Hampshire	245
Ohio	84	Michigan	125	North Carolina	255
Minnesota	85	New Jersey	130	Idaho	260
Montana	90	Oklahoma	130	Texas	288
Oregon	90	West Virginia	135	South Dakota	320
Utah	91	Pennsylvania	137	Alabama	470
Connecticut	95	Louisiana	168	Kentucky	473
Colorado	98	Georgia	173	Arkansas	488
Missouri	105	Vermont	174	Mississippi	1090

There are no orthopaedic surgeons in Nevada, New Mexico, and Wyoming listed in the American Medical Directory.

Thus we see a vast difference in the distribution of orthopaedic surgeons.

Why should there be such a wide disproportion in distribution?

Several factors may contribute and each state should be investigated by the prospective practitioner. The following possible causes should be pointed out:

1. A disproportion in income between various areas. The states with the largest number of orthopaedic surgeons proportionally have the highest incomes, and those with the fewest orthopaedic surgeons have the lowest.

2. Density of population plays a definite part. The states without an orthopaedic surgeon have the fewest people per square mile. Furthermore there are no cities of over 30,000 in these states and only twenty-eight cities have a population of 2500 or more.

3. The importance of a metropolitan center is of great moment. Arizona, with a population about as sparce as that of New Mexico, has two fair-sized cities, and supports three orthopaedic surgeons that I know of, one of whom uses a plane in reaching consultations at outlying points. All cities of 250,000 or more are adequately supplied with orthopaedic surgeons. Five cities of over 100,000 (census of 1930) have no orthopaedic surgeons (Tampa, Florida; Cambridge, Lowell, and Somerville, Massachusetts; and Yonkers, New York). Of these only Tampa and Lowell can be considered remote from large cities. Half of the cities with populations between 50,000 and 100,000 have no resident member of the American Orthopaedic Association or the American Academy of Orthopaedic Surgeons, or Diplomates of the American Board of Orthopaedic Surgery, and might prove fertile fields for younger men. It should be noted, however, that many of these cities are only suburbs of larger cities, and the work flows into the larger city. A city of 30,000, not in a metropolitan area, with a good back country, may form an adequate center for orthopaedic work.

4. Closely related to the last factor is the character of hospital facilities. Many fine hospitals in the smaller cities, I find, are poorly equipped for orthopaedic surgery, and the nursing staffs are unfamiliar with our techniques.

5. Climate undoubtedly influences the choice of some men.

6. The presence of institutions—medical schools and clinics—is likely to draw men to communities that are intrinsically unimportant, such as Iowa City, Iowa, and Rochester, Minnesota.

7. A study of the ratio between orthopaedic surgeons and medical practitioners reveals a national average of 1:144. The number of general practitioners to each orthopaedic surgeon in individual states is as follows:

Washington	70	West Virginia	130	North Carolina	190
Delaware	81	Oklahoma	131	Hawaii	205
Minnesota	85	South Carolina	135	Florida	207
North Dakota	85	District of Columbia	138	Idaho	213
Montana	87	Connecticut	139	Iowa	221
Maryland	88	Arizona	140	Indiana	226
Utah	94	*General Average*	*144*	Texas	242
Nebraska	95	Michigan	146	Maine	246
California	109	Missouri	147	Vermont	250
Ohio	111	Georgia	153	New Hampshire	328
Oregon	114	Rhode Island	156	Alabama	348
Tennessee	121	Colorado	160	Kentucky	460
New York	122	Kansas	164	Arkansas	462
Wisconsin	122	New Jersey	169	Mississippi	747
Virginia	128	Illinois	175	Louisiana	169
Massachusetts	129	Pennsylvania	183	South Dakota	267

There are no orthopaedic surgeons for Nevada, New Mexico, and Wyoming listed in the American Medical Directory.

A high ratio combined with a large population per practitioner would indicate either a relatively poor population, a very healthy area, or one in which reference work was uncommon. One might check any specific area against a more established specialty such as ophthalmology or otolaryngology.

The young man should ask concerning the near future of any area. At present our institutions are training about eighty men a year capable of qualifying for the certificate of the American Board of Orthopaedic Surgery. The average age for beginning practice is thirty years. The average age of retirement or death is about sixty-four years. Assuming that there are no radical changes in birth, death, and immigration rates, in thirty

years this country will have a population in the neighborhood of 155,000,000. Assuming similar factors about orthopaedic surgeons, we shall have by 1970 about 2600 orthopaedic surgeons; or one to every 58,000 population, about twice as many as exist today. This would place the whole country in the overcrowded condition of California and the other states at the top of the list.

With this as a prospect for the future, what other factors should be investigated?

1. What is included in the subject of orthopaedic surgery by the men of the proposed community?

The limitation of orthopaedic surgery to deformities and disabling motor diseases, with the elimination of traumatic conditions, would cut the required orthopaedic surgeons to about 10 per cent. of the present number. The inclusion of traumatic surgery brings one into competition with general and industrial surgeons, and with many general practitioners. Pioneering in a smaller community remote from a metropolitan area is likely to be a Herculean task.

2. One should consider the commercial geography of the location. A highway and railroad center would be better than a town just on the road.

3. An investigation should be made of the group of orthopaedic surgeons in the particular community that one is interested in. Let us compare two saturated areas, Metropolitan Los Angeles and the San Francisco Bay area. There are about 50,000 persons per orthopaedic surgeon in the former and 40,000 in the latter area. Breaking the orthopaedists into age groups one finds 40 per cent. of the San Francisco men are beyond fifty years of age while only about 20 per cent. of the Los Angeles group are that old. Nearly half the men in Los Angeles and less than 20 per cent. in the San Francisco area are under forty. Apparently San Francisco could stand some new blood sooner than Los Angeles, but neither area can stand any more orthopaedic surgeons at present. If none came for fifteen years conditions would tend to improve for all. If any community should suddenly exhibit a phenomenal growth, prospects might be radically altered.

The study suggests that our national Associations should try to prevent the glutting of the market for the sake of cheap help, as occurred in the nursing profession a decade or more ago.

The use of the directory of the American Board of Orthopaedic Surgery, the American Medical Directory, the World Almanac, and a good road map will be of great help in making a satisfactory analysis of a given area. Finally a studious visit to the prospective area would be advisable.

STEELE F. STEWART

3780 Wilshire Boulevard
Los Angeles, California

News Notes

The Ninth Annual Convention of **The American Academy of Orthopaedic Surgeons** will be held in New Orleans, Louisiana, on January 13, 14, 15, and 16, 1941, under the presidency of Dr. Robert D. Schrock of Omaha. The headquarters will be the Hotel Roosevelt.

On Monday morning, January 13, a clinical program will be presented at the Hutchinson Memorial Building, Tulane Medical School, by the local members of the Academy.

The following scientific program has been arranged:

TUESDAY, JANUARY 14

Morning Session

Localized Fibrocystic Disease of Bone.
Rufus H. Alldredge, M.D., New Orleans, Louisiana.
Discussion: Walker E. Swift, M.D., New York, N. Y.
Philip D. Wilson, M.D., New York, N. Y.

Aseptic Necrosis and Bone Drilling.
Ernst Bergmann, M.D., New York, N. Y. (By invitation.)
Arthur Krida, M.D., New York, N. Y.
Discussion: Frank N. Potts, M.D., Buffalo, New York.

Operative Treatment of Legg-Perthes Disease.
Paul B. Steele, M.D., Pittsburgh, Pennsylvania.
Discussion: A. Bruce Gill, M.D., Philadelphia, Pennsylvania.
M. Beckett Howorth, M.D., New York, N. Y.
Charles W. Peabody, M.D., Detroit, Michigan.

Thrombophlebitis and Postphlebitic Oedema.
Alton Ochsner, M.D., New Orleans, Louisiana. (By invitation.)

Congenital Pseudarthrosis.
Harold B. Boyd, M.D., Memphis, Tennessee. (By invitation.)
Discussion: Paul C. Colonna, M.D., Oklahoma City, Oklahoma.

Shelf Operation at the Hip: New Method.
Edwin W. Ryerson, M.D., Chicago, Illinois.
Discussion: Frank D. Dickson, M.D., Kansas City, Missouri.
C. H. Crego, Jr., M.D., St. Louis, Missouri.

An Evaluation of Physiotherapy in Early Treatment of Anterior Poliomyelitis.
H. R. McCarroll, M.D., St. Louis, Missouri.
C. H. Crego, Jr., M.D., St. Louis, Missouri.
Discussion: Oscar L. Miller, M.D., Charlotte, North Carolina.
J. Albert Key, M.D., St. Louis, Missouri.

Afternoon Session

Classification of Bone Tumors According to Radiosensitivity.
Murray Copeland, M.D., Baltimore, Maryland. (By invitation.)

Gradation of Ewing's Tumors.
Willis C. Campbell, M.D., Memphis, Tennessee.
J. F. Hamilton, M.D., Memphis, Tennessee.

Hemangioma of the Vertebra.
R. K. Ghormley, M.D., Rochester, Minnesota.
A. W. Adson, M.D., Rochester, Minnesota.
Discussion of the above three papers:
Robert D. Schrock, M.D., Omaha, Nebraska.
Alan DeForest Smith, M.D., New York, N. Y.

End Results of 200 Cases of Suppurative Arthritis.
John A. Heberling, M.D., Pittsburgh, Pennsylvania.
Discussion: Jacob Kulowski, M.D., St. Joseph, Missouri.
Carl E. Badgley, M.D., Ann Arbor, Michigan.
The Use of Neoarsphenamine in the Treatment of Acute Osteomyelitis with Associated Staphylococcus Septicaemia: A Clinical and Experimental Study.
Edward Le Cocq, M.D., Seattle, Washington.
Discussion: A. R. Shands, Jr., M.D., Wilmington, Delaware.

WEDNESDAY, JANUARY 15

Morning Session

An Accurate Method for the Estimation of the Expected Growth of the Femur and Tibia in Individual Children.
Gerald G. Gill, M.D., San Francisco, California. (By invitation.)
A Study of End Results in Bone-Lengthening.
Beveridge H. Moore, M.D., Chicago, Illinois.
Discussion of the above papers:
LeRoy C. Abbott, M.D., San Francisco, California.
J. Warren White, M.D., Greenville, South Carolina.
The Timing of the Fracture-Healing Process: Its Influence on Choice and Application of Treatment Methods.
Clay Ray Murray, M.D., New York, N. Y.
Discussion: Melvin S. Henderson, M.D., Rochester, Minnesota.
J. Albert Key, M.D., St. Louis, Missouri.
Relationship of the Periosteum to the Repair of Bone.
John R. Moore, M.D., Philadelphia, Pennsylvania.
Dr. Steinbergh, Philadelphia, Pennsylvania.
Discussion: Philip Lewin, M.D., Chicago, Illinois.
Guy W. Leadbetter, M.D., Washington, D. C.
The Fate of Fascia Lata in Knee-Joint Reconstruction: Histological Study.
E. T. Evans, M.D., Minneapolis, Minnesota.
Discussion: Wallace H. Cole, M.D., St. Paul, Minnesota.
Comparison of Stainless Steel and Vitallium as Material for Internal Fixation of Bone.
J. Albert Key, M.D., St. Louis, Missouri.
Discussion: Walter G. Stuck, M.D., San Antonio, Texas.
Use of Vitallium Ferrule to Alleviate Lesions of the Head of the Radius.
Kellogg Speed, M.D., Chicago, Illinois.
Discussion: Harold R. Bohlman, M.D., Baltimore, Maryland.
M. N. Smith-Petersen, M.D., Boston, Massachusetts.
Fracture of the Patella Treated by Removal of the Fragments: End Results.
J. E. M. Thomson, M.D., Lincoln, Nebraska.
Discussion: Edward Harlan Wilson, M.D., Columbus, Ohio.
E. J. Berkheiser, M.D., Chicago, Illinois.
Some Mechanical Derangements of the Knee.
Allen F. Voshell, M.D., Baltimore, Maryland.
Otto C. Brantigan, M.D., Baltimore, Maryland.

Afternoon Session

Organization for Evacuation and Treatment of War Casualties.
N. T. Kirk, M.D., Washington, D. C.
Discussion: Philip D. Wilson, M.D., New York, N. Y.
Harold R. Conn, M.D., Akron, Ohio.
George E. Bennett, M.D., Baltimore, Maryland.
President's Address.
Robert D. Schrock, M.D., Omaha, Nebraska.

Conservative and Operative Treatment of Fractures of the Carpal Scaphoid.
K. O. Haldeman, M.D., San Francisco, California.
Ralph Soto-Hall, M.D., San Francisco, California.
Discussion: E. F. Cave, M.D., Boston, Massachusetts.
Use of Preserved Bone Grafts in Orthopaedic Surgery.
Alberto Inclán, M.D., Havana, Cuba.
Discussion: Fred H. Albee, M.D., New York, N. Y.
Treatment of Calcified Tendinitis.
Joseph E. Milgram, M.D., Brooklyn, New York.
The Public Care of the Physically Handicapped.
Fred H. Albee, M.D., New York, N. Y.

THURSDAY, JANUARY 16

Morning Session
The Rib Joints.
Joel E. Goldthwait, M.D., Boston, Massachusetts.
The Rôle of Curare in the Prevention of Fractures in Convulsive Metrazol and Insulin Shock Therapy.
W. R. Hamsa, M.D., Omaha, Nebraska.
Discussion: M. E. Pusitz, M.D., Topeka, Kansas.
Edgar D. Oppenheimer, M.D., New York, N. Y.
Experimental Studies in the Use of a "U" Clamp for Approximation and Fixation of Spinous Processes in Vertebral Fractures.
Robert V. Funsten, M.D., Charlottesville, Virginia.
Discussion: R. Nelson Hatt, M.D., Springfield, Massachusetts.
Arthur G. Davis, M.D., Erie, Pennsylvania.
Surgery of the Intrinsic Muscles of the Hand Other than Those of Opposition of the Thumb.
Sterling Bunnell, M.D., San Francisco, California.
Discussion: Arthur Steindler, M.D., Iowa City, Iowa.
A New Operation for Acromioclavicular Dislocation.
E. B. Mumford, M.D., Indianapolis, Indiana.

Executive Sessions will be held at noon on Tuesday and at eleven o'clock on Thursday.

Dr. Hugh T. Jones announces the association with him of Dr. John R. Black. Their address is 909 Wilshire Medical Building, 1930 Wilshire Boulevard, Los Angeles, California.

Dr. Philip I. Burack, formerly of Columbus, Ohio, is now located at 1085 Park Avenue, New York City.

Dr. G. Mosser Taylor and his associate, Dr. Alonzo J. Neufeld, have moved their offices to 1216 Wilshire Boulevard, Los Angeles, California.

The 1940 meeting of the **Clinical Orthopaedic Society** was held in Milwaukee, Wisconsin, on October 18, and in Madison, Wisconsin, on October 19. The newly elected officers of the Society are as follows: President, Dr. Fremont A. Chandler; Vice-President, Dr. Herman C. Schumm; Secretary-Treasurer, Dr. Myron O. Henry. The 1941 meeting will be held in Cleveland, Ohio.

The **Orthopaedic Forum** held its Eleventh Annual Meeting in New York on October 24 and 25. The morning of the first day was spent at the Hospital for Joint Diseases and the afternoon at St. Luke's Hospital. The next day was spent at the Mountainside Hospital in Montclair, New Jersey. The attendance at the meeting was 100 per cent.

The Orthopaedic Guild held its Sixth Annual Meeting in New York City on November 1 and 2. The sessions were held at the New York Post-Graduate Medical School and Hospital, and at the New York Orthopaedic Hospital. An interesting program was presented.

The fourth meeting of the orthopaedic society previously known as the Orthopaedic Forum was held in Columbus, Ohio, on Friday, November 22, at the White Cross Hospital. A very interesting program was presented by the host orthopaedic surgeons.

Because the name "Orthopaedic Forum" had been in use for some time by a larger and older organization, it was decided to change the name to the **Tri-State Orthopaedic Society**. The next meeting will be held in April, 1941, in Fort Wayne, Indiana.

The registered attendance at the Sixty-Ninth Annual Meeting of the **American Public Health Association** and meetings of related organizations held in Detroit the week of October 7 was 3,187, second largest in the Association's history. Delegates came from every state in the Union, the District of Columbia, Alaska, Hawaii. Puerto Rico, Canada, Cuba, Mexico, Denmark, China, and New Zealand.

The officers elected for the year 1940–1941 are as follows: President, W. S. Leathers, M.D., Nashville, Tennessee; President-Elect, John L. Rice, M.D., New York, N. Y.; Vice-Presidents, Robert D. Defries, M.D., Toronto, Canada, Charles Edward Finlay, M.D., Havana Cuba, and Selskar Gunn, New York, N. Y.; Treasurer, Louis I. Dublin, Ph.D., New York, N. Y.: Chairman of the Executive Board, Abel Wolman, Dr.Eng., Baltimore, Maryland; and Executive Secretary, Reginald M. Atwater, M.D., New York, N. Y.

A Committee on Public Health in the National Defense was appointed. with W. S. Leathers, M.D., Chairman.

Among the resolutions passed was one emphasizing the necessity for maintaining civilian health as essential in national defense and pledging the united support of members to the national defense and to the maintenance of health in a free people.

The Seventieth Annual Meeting will be held in Atlantic City, New Jersey, in October, 1941.

The **Mississippi Valley Medical Society** offers annually a cash prize of $100.00, a gold medal, and a certificate of award for the best unpublished essay on any subject of general medical interest and practical value to the general practitioner of medicine. Certificates of merit may also be granted to the physicians whose essays are rated second and third best. Contestants must be members of the American Medical Association and residents of the United States. The winner will be invited to present his contribution before the next annual meeting of the Mississippi Valley Medical Society at Cedar Rapids, Iowa, October 1, 2, and 3, 1941. The Society reserves the exclusive right to publish the essay first in its official publication—the Mississippi Valley Medical Journal. Contributions should not exceed 5,000 words, should be typewritten in English in manuscript form, submitted in five copies, and must be received not later than May 1, 1941. Further details may be secured from Harold Swanberg, M.D., Secretary, Mississippi Valley Medical Society, Quincy, Illinois.

Current Literature

Bone Graft Surgery in Disease, Injury, and Deformity. By Fred H. Albee, M.D., LL.D., Sc.D., F.A.C.S., F.I.C.S., assisted by Alexander Kushher, M.D., B.Sc. New York, D. Appleton-Century Co., Inc., 1940. $7.50.

This book is such a valuable addition to the bookshelf of any orthopaedic surgeon, that he cannot afford to be without it. The volume is readable and the author's arguments in support of his technique are clear. There are approximately 400 pages, covering the general principles of bone-grafting in nine chapters, and, in addition, an index of authors and subjects. It is the type of book that does not lend itself well to a critical review and must be read to be appreciated.

The author states, "There are incorporated those procedures which have stood the test of time: namely, those which I have used myself and those which I have not elected to use myself but have included because of their employment by experienced surgeons of mature judgment."

Dr. Albee, like all pioneers, is chiefly concerned with proving that a certain procedure is possible. After all, this is as it should be; those who follow the pioneers' methods and techniques ultimately establish or disprove their worth. However, after reading the book, one feels that the author, who has had such a vast experience, should have included another chapter (a short summary, so to speak) which would have dealt with the dangers and pitfalls in bone-graft surgery. It is true that these are mentioned in the text under various headings, but if they had been assembled concisely under one head, it would have been a distinct addition to the book.

The chapter on the general principles of bone-grafting is excellent and the chapter on armamentarium is exceedingly interesting. Few surgeons would have the patience and ingenuity to carry out the many complicated cabinet-making types of procedures for the use of the graft which the author advocates. In discussing the source of the bone for spine fusion, the author claims that, and gives reasons why, the tibia is the source of choice. The author advances the theory that the bone graft in spine fusion probably has a far-reaching effect beyond the mere immobilization, because of the linking up of the circulation of the cancellous tissue in each affected vertebra with that of its neighbor and, through the graft, with that of the healthy vertebrae adjoining the affected area.

The chapter on spine fusion is replete with suggestions of technique original with the author, but he has also included in this chapter the techniques of Hibbs and Girdlestone. His arguments for the use of the bone graft in tuberculosis and scoliosis are far more convincing than those for its use in fractures of the spine.

In fractures of the neck of the femur, Dr. Albee recommends the bone graft for selected cases of fresh fractures, and for all cases of ununited fractures where the capital fragment is of sufficient length to receive it favorably. Some might take exception to the unqualified statement that it is absolutely essential to open all ununited fractures of the neck of the femur and remove the tissue from between the bone fragments. There have already been several series of carefully recorded cases by other surgeons on the use of the bone graft by extra-articular osteosynthetic methods wherein the joint is not opened, and their results compare favorably with those of others using the open method.

The author goes into considerable detail concerning his reconstruction operation for ununited fracture of the neck of the femur, where the non-union has been of long duration and accompanied by much erosion of the capital fragment. This reconstruction operation consists of removing the head of the femur, as in the Whitman procedure, but in addition Dr. Albee provides a bone lever which should be about four inches long, and should protrude laterally, so that the short trochanteric muscles are left intact on the trochanter or proximal end of the lever.

That portion of the book devoted to ununited fractures treated by the aid of the

tions, considerations of diagnosis, guides for procedures, and details of techniques which have been employed or described by surgeons of large experience are given special attention.

The scope of the subjects allows an inclusive list of practically all the conditions which come under the care of the orthopaedic and traumatic surgeon. The book is a definite addition to the group of Year Books and the demand for it will certainly ensure its permanency.

Surgery of the Hand. R. M. Handfield-Jones, M.C., M.S., F.R.C.S. Baltimore, The Williams & Wilkins Co., 1940. $4.50.

This book of 140 pages is dedicated to Allen B. Kanavel and to the Casualty House Surgeons, past, present, and future, of St. Mary's Hospital, London. The writer is a great admirer of Kanavel and his works. He feels, however, that Kanavel's book has confused the general practitioner by mixing too much experimental work with the clinical. Handfield-Jones has tried to simplify the subject as much as possible. Great stress has been laid on exact diagnosis, a careful study of the anatomy of the part, and on the principles of treatment.

His general principles of treatment are worth noting:

"1. Never make an incision until the presence of pus is certain.
2. Never make an incision until its exact situation is known.
3. Always operate under full anaesthesia.
4. Always use an air-compression tourniquet.
5. Never make an incision on the dorsum until every other possible site of pus has been eliminated.
6. Always use soft rubber tissue for drainage, never a tube.
7. After forty-eight to seventy-two hours change from hot fomentations to paraffin and flavine dressings.
8. Concentrate upon retention or restoration of full movements.
9. Encourage patient to make movements the hobby of convalescence.
10. When lymphangitis or tenosynovitis is diagnosed, immediately use sulphonamide without waiting for a bacteriological report."

Ninety-five excellent illustrations add to the value of the volume.

Körperliche Missbildungen (Skeletal Anomalies). Dr. Hellmut Eckhardt. [Handbuch der Erkrankheiten, Band VI, von A. Gütt.] Leipzig, George Thieme, 1940. 24 marks.

This monograph constitutes the second portion of Volume 6 of the Handbook of Hereditary Diseases, published under the editorship of Dr. A. Gutt. The author, in his introductory remarks, notes that where formerly the function of the physician was the care of the individual patient, his present purpose is the improvement of the health of the German people, in accordance with the methods of the National Socialist State.

However, it should not be presumed that the volume contains any therapeutic suggestions. Throughout the volume the author is absorbed in discussing his topics purely with the object of demonstrating the hereditary nature of a number of different conditions. This is not carried out in any critical manner, but mainly by reference to other authors who seem to confirm the theory of inheritance. Where other explanations, such as endocrine imbalance, may be the etiological factor, the author implies that this imbalance is in truth of hereditary origin, and so the matter is again settled. A few typical genealogical charts with circles in black and white complete the proof. What discussion of the mechanism of the inheritance there is, is presented sketchily and by implication.

Apart from this, the monograph presents the subject of dyschondroplasias, osteo-

genesis imperfecta, the syndrome of the mesodermal dystrophies, anomalies of the vertebral column, hands and feet, congenital dislocation of the hips, club-foot, hare-lip, etc., in a pleasing and easily readable manner. The general features of the various conditions are described in broad general terms, so that the relationship between many obscure conditions is more easily comprehended. No therapeutic indications of any kind are given. The references for the discussion of each condition are appended at the end of the volume.

ARTHRITIS AND ALLIED CONDITIONS. Bernard I. Comroe, A.B., M.D., F.A.C.P. Philadelphia, Lea & Febiger, 1940. $8.50

The book is excellent, concise, carefully edited, and simple. It is designed not only for the general practitioner, but for the specialist who can use it as an authoritative textbook. It covers all the aspects of the arthritic problem, and has an excellent reference system, based on an extensive study of the literature, which is of great service for further study.

Arthritis is a difficult subject to handle, and Dr. Comroe has handled such controversial subjects as classification, the significance of the sedimentation rate, and the differential diagnosis in a clear, practical way by giving the best that is known at the present time. The short summary tables, conspicuously outlined, are excellent. Although the statements are didactic, they serve a purpose and are practical, containing the up-to-date facts.

Such chapters as Chapter Four on Etiology and Chapter Seven on General Treatment are good. Every physician would do well to read and absorb these general ideas of treatment. Chapter Eight on Diet clears the air considerably about this much disputed subject. In Chapter Nine the advice about infection is sound, and the evaluation is important.

Orthopaedic Care of Rheumatoid Arthritis gives the general practitioner a practical working basis, and a picture of what to do and what to keep in mind. The point of view taken about the treatments by iontophoresis, vaccines, sulphur, gold, and other drugs are of real value. There are chapters on gout, backache, bursitis, sciatica, gonorrhoea, fibrositis, even flat feet and tumors, all of which, though not arthritis, confuse the picture and make diagnosis difficult.

The book is well written, easily read, and well put together. It is primarily a textbook and a compilation. The purpose of the book, in trying to evaluate practical methods of treatment from the enormous amount of literature which has been written of late, is well carried out. The author has succeeded in eliminating himself from the book and writes impersonally as a collector and critic. The illustrations are well chosen. The book should serve a very useful purpose, and it is well worth owning.

FRACTURES AND DISLOCATIONS FOR PRACTITIONERS. Edwin O. Geckeler, M.D. Ed. 2. Baltimore, The Williams & Wilkins Co., 1940. $4.00.

This book is a second revised edition of the foolproof procedures for practitioners which appeared three years ago. In its 307 pages, there are 267 figures, including 131 roentgenograms. There is described at least one reliable method of treatment for each fracture or dislocation that a practitioner is apt to meet in any busy accident service. Special emphasis has been placed on the use of skeletal traction and the treatment of compound fractures. The value of follow-up treatment is discussed.

Since the appearance of the first edition three years ago, there has been considerable progress in traumatic surgery due to a number of factors, among which are the ever-increasing number of automobile accidents, and the expansion of industrial accident clinics. The new edition has taken note of these changes, enlarging certain subjects to keep abreast of the latest advances, and adding a total of seventy photographs and roentgenograms. Adequate references to articles and books are listed at the conclusion of each subject.

tions, considerations of diagnosis, guides for procedures, and details of techniques which have been employed or described by surgeons of large experience are given special attention.

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Some rather radical changes have been made which perhaps will not meet with universal endorsement. In spelling, diphthongs have been eliminated, hyphenated words are indicated as one word, and the letter "k" has been substituted for "c" in many words. These, however, are unimportant details and do not in any way detract from the value of the work.

This book will be found helpful to those who have occasion to look up medical terms with their pronunciation and derivation, and also to those who are looking for information on some of the medical subjects. It will be of value and interest to all practicing physicians and surgeons, and almost indispensable to libraries.

STUDIES ON DYSPLASTIC ACETABULA AND CONGENITAL SUBLUXATION OF THE HIP JOINT WITH SPECIAL REFERENCE TO THE COMPLICATION OF OSTEOARTHRITIS. Gunnar Wiberg. *Acta Chirurgica Scandinavica*, LXXXIII, Supplementum LVIII, 1939.

Subluxation of the hip is established as a permanent deformity which may be identified in children by the location of the capital osseus center, dysplasia of this center, and increase in the angle of inclination of the acetabulum. Arthrography with the injection of a contrast medium has permitted a more accurate study of joint details. However, there is difficulty in establishing the diagnosis of subluxation in adults, and the writer offers a method based on the measurement of an angle between a vertical line through the center of the head, and another line through the center of the head and the lateral border of the acetabular roof. An angle of less than 20 degrees indicates defective development.

In following thirty-eight hip joints from childhood to seventeen years of age, the writer found five maldeveloped hips which became normal without treatment. Three hips which had originally been considered normal became defective. Nineteen subluxated hips were followed before and after the development of osteo-arthrosis, and several series of roentgenograms are reproduced. Of the cases of osteo-arthrosis seen over a two-year period, one-fourth appeared to have been due originally to subluxation.

In twenty-eight cases of subluxation which had had shelf operations, one was unimproved, six slightly improved, sixteen considerably improved, and five cured. Two developed osteo-arthrosis in spite of the operation.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

EXPERIMENTELLE UNTERSUCHUNGEN ÜBER DIE OSTEOGENESE UND DIE BIOCHEMIE DES FRACTURCALLUS (Experimental Investigation of Osteogenesis and the Biochemistry of Callus). Svante Annersten. *Acta Chirurgica Scandinavia*, LXXXIV, Supplementum LX, 1940.

On the basis of the literature, animal experimentation, and clinical findings, the writer offers a detailed account of the causation of osteogenesis, and the chemistry and mechanism of ossification. He gives up hope of discovering the mechanism of the formation of callus on the basis of morphology. He proves that bone can be formed in normal muscle by the injection of a non-specific, thermostable (up to 78 degrees centigrade) alcohol, ether, or benzol extract of normal bone. This suggests that in the formation of callus the osteogenetic substance as well as the calcium comes from local bone fragments.

The local chemical process of ossification of callus is discussed in detail. In the first few days after the fracture, there is a rapid increase in the phosphorus content of the surrounding musculature. After about seven days the calcium content rises more rapidly than the phosphorus, until the calcium-to-phosphorus ratio of somewhat more than twice that of adult bone is reached. The phosphorus content of blood plasma, unlike the calcium content, increases during callus formation.

The increase of insoluble carbonate comes at a later stage of callus ossification. Increase in bicarbonate appears early, perhaps with a beneficial local alkalizing effect. Hydrogen-ion determinations show that as callus ages, there is an appreciable increase in alkalinity. This alkalinity favors the deposition of tertiary calcium phosphate, and the

activity of phosphatase which is increased in amount in callus.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

TRANSITORY SYNOVITIS OF THE HIP JOINT IN CHILDREN. Solomon Rauch. *Am. J. of Diseases of Children,* LIX, 1245, June 1940.

This condition is described as a non-specific, relatively transient inflammation of the synovial membrane of the hip joint of a child. The onset may be acute or insidious, and, clinically, there are symptoms of pain, limp, or unwillingness to walk, and restriction of motion, especially in abduction, extension, and internal rotation. Laboratory evidence of infection, positive tuberculin reaction, and roentgenographic evidence of abnormality are all lacking. The treatment is conservative, and the prognosis for functional recovery excellent. Nearly all recover with two or more weeks in bed.

The author goes thoroughly into the previous literature on the subject, as well as into multitudinous points of differential diagnosis. Forty conditions are listed resembling transitory synovitis of the hip joint, although tuberculous coxitis is given the most emphasis in the discussion.

Thirty-seven case histories are presented in tabular form and various correlations made from the facts. The duration of the condition was from seven to sixty days, with an average of thirty-two days.—*John D. Blair, M.D., Iowa City, Iowa.*

CONDROMIXOOSTEOSARCOMA DELL'ALLUCE (Chondromyxo-osteosarcoma of the Great Toe). Carlo Uggeri. *Annali Italiani di Chirurgia.* XIX, 21, 1940.

A peasant, sixty-seven years old, had noticed for about ten years a painless swelling of his left great toe. Three months before consulting the author a stone he was carrying fell on the toe. The swelling increased and a blue discoloration around the nail remained. He had severe pain which did not subside. About two weeks after the accident an ulceration developed. A disarticulation in the metatarsophalangeal joint was performed. The histological examination showed the interesting feature of a benign chondromyxoma together with some fresh spots of malignant sarcomatous degeneration within the same slide.—*Joseph Wolf, M.D., Davenport, Iowa.*

ANEURISMA CIRSOIDE CONSEGUENTE A TRAUMA (Cirsoid Aneurysm Following Trauma). Carlo Uggeri. *Annali Italiani di Chirurgia.* XIX, 177, 1940.

A case of racemose aneurysm of the left ring finger is described. A man, thirty-four years old, had noticed for twenty-four years that the left ring finger became blue when his hand hung down or was in cold water, and that the discoloration disappeared when the hand was elevated. He also noticed that in summer the volar side of the ring finger perspired more than the other fingers and palm. A year and a half before he was first seen, the tips of four fingers of the left hand were squeezed between a fallen tree and the stump. The pain in the other injured fingers subsided quickly but remained constant in the ring finger where a tumor developed. The examination revealed a tumor with pulsation around the middle phalanx, and the roentgenogram showed partial destruction of the distal end of the first phalanx. The operation and histological examination verified the diagnosis of cirsoid aneurysm.—*Joseph Wolf, M.D., Davenport, Iowa.*

PLASTICHE CON LAMINE DI GOMMA IN LESIONI ARTICOLARI SPERIMENTALI (Plastics with Sheet Rubber in Experimental Articular Lesions). G. Giangrasso. *Annali Italiani di Chirurgia.* XIX, 289, 1940.

The author reports the use of sheet rubber in arthroplastics in a number of experiments on dogs. A material used for this purpose should prevent the proliferation of osseous and periosteal tissue; further the coverage of the raw bone with firm connective

tissue and, thereby, a complete fusion of the covering material with the denuded bone; and finally induce the production of a lubricant having as nearly as possible the qualities of synovial fluid. Sheet rubber, in experiments on the knee joints of dogs, proved to be superior to other media. It is sterilized in distilled water for thirty minutes, boiled a few minutes in a 3-per-cent. phenol solution, and then boiled again in distilled water for fifteen minutes. Sheet rubber gave better results than sponge rubber. It does not irritate the tissues of the joints and in no case was there suppuration or a fistula. For clinical use it proved of value in ankylosis of the mandible. Only fascia lata proved to be of equal value, and it had the additional advantage of more rapidly producing connective tissue to cover the planes of the joint.—*Joseph Wolf, M.D., Davenport, Iowa.*

SULL'ALLUNGAMENTO OPERATIVO DEL FEMORE (Operative Lengthening of the Femur). A. Mezzari and L. Trivelli. *Archivio di Ortopedia.* LV, 452, 1939.

This is a report on eight cases,—seven of tuberculosis of the hip or knee and one of infantile paralysis—in which an operative lengthening of the femur was performed. In tuberculosis the upper third of the femur is the site of the operation; in infantile paralysis the lower third is preferred, since not only a lengthening but a slight posterior angulation at the site of the osteotomy benefits an unstable knee. The patients were between ten and twenty-two years of age, the shortening between 5 and 13 centimeters, the amount of the operative lengthening averaged 4.87 centimeters. Two holes for wires for traction are drilled through the trochanter and the lower metaphysis respectively. A simple oblique osteotomy is preferable to a Z-shaped one. The lengthening is effected by means of progressively increased screw traction starting with 3 to 4 kilograms and increasing up to 20 kilograms after three weeks. In two cases complications—in one infection around the wires, and in the other paralysis of the sciatic nerve—delayed the result which, however, was finally excellent in all cases.—*Joseph Wolf, M.D., Davenport, Iowa.*

SUBLUSSAZIONE ABITUALE DI DIARTROSI FRA I PROCESSI ARTICOLARI DELLE VERTEBRE LOMBARI IV E V (Recurrent Subluxation of the Diarthroses between the Articular Processes of the Fourth and Fifth Lumbar Vertebrae). Camillo Corradi. *Archivio di Ortopedia.* LV, 459, 1939.

A case is described of recurrent subluxation of the right intervertebral joint between the fourth and fifth lumbar vertebrae, in a man thirty-two years of age, following an automobile accident. It was similar to the one described by Hadley in *The Journal of Bone and Joint Surgery* (XVIII, 428, April 1936), except for the fact that the lower articular facet of the fourth lumbar vertebra was dislocated toward the head ("dislocatio cum distractione"), while in Hadley's case the dislocation was in the caudal direction ("dislocatio cum contractione"). The dislocation was marked in roentgenograms taken in a kyphotic position but disappeared with a maximal lumbar lordosis. The diagnosis of this rare dislocation depends on good roentgenograms taken from different angles with the lumbar spine in kyphotic and in lordotic positions.—*Joseph Wolf, M.D., Davenport, Iowa.*

OSTEOCONDRITE DISSECANTE BILATERALE DEL GINOCCHIO (contributo clinico ed istologico) [Bilateral Osteochondritis Dissecans of the Knee Joint (Clinical and Histological Study)]. M. Dragonetti, *Archivio di Ortopedia.* LV, 533, 1939.

To the five cases of bilateral osteochondritis dissecans of the knee joint which so far have been reported in the literature, the author adds the description of a man twenty-four years old. There was no history of trauma, and the destructive process went on over a period of one and one-half years. The roentgenographic appearance was the same on both sides. These facts speak for the theory of the endocrinological etiology of the disease and against that of the traumatic, a question which is still debated in the literature.—*Joseph Wolf, M.D., Davenport, Iowa.*

Contributo alla conoscenza radiologica delle alterazioni del tendine terminale del muscolo sottoscapolare: il distacco patologico dell'inserzione trochiniana e la rottura parziale del tendine ossificato (Contribution to the Roentgenographic Diagnosis of the Changes in the Tendon of the Subscapularis Muscle: the Pathological Evulsion of the Insertion at the Trochin and Partial Rupture of the Ossified Tendon). Camillo Corradi. *Archivio di Ortopedia.* LV, 545, 1939.

Two rare cases of injuries to the subscapularis tendon are described. A man thirty-two years of age was forming a curve in an iron wire with pliers and rotating his right arm inward when he felt a sudden sharp pain in the shoulder. The roentgenogram showed destruction of the outer upper quadrant of the neck of the humerus and separation of the major tubercle. The destruction of the bone was due to tuberculosis. The author believes his case of pathological evulsion fracture of the major tubercle of the humerus to be the first reported in the literature. The other case is that of a man, forty-eight years of age, who fell from a bicycle on his right shoulder. The clinical and roentgenographic diagnosis was anterior dislocation of the head of the humerus and partial rupture of the ossified tendon of the subscapularis muscle. The author was also unable to find another case of this combination in the literature.—*Joseph Wolf, M.D., Davenport, Iowa.*

Influence of Fusion of the Spine on the Growth of the Vertebrae. S. L. Haas. *Archives of Surgery,* XLI, 607, Sept. 1940.

In the growing spinal column what happens to the growth when the spinous processes are fused?

With this question in mind, Haas studied the effects of spinal fusions in young dogs. In five instances the spinal fusions were performed by the Hibbs technique, and in twelve by the Albee technique. Modifications of these procedures were used in five other experimental animals.

It was found that the vertebrae continued to grow in length until the fusion became firm. The Hibbs operation, with its mass of soft callus, allowed greater growth than the Albee operation with its fixed graft, but growth continued even after the fusion was solid. However, because the elongation was greater in the anterior part of the bodies of the vertebrae than in the posterior part, a lordosis developed with compression of the intervertebral discs and premature ossification of the epiphyseal cartilaginous plates, particularly near the posterior portions of the bodies. Haas calls attention to the fact that these changes are much more pronounced in dogs than they are likely to be in humans, because the growth of the spinal column is quite rapid in the experimental animal, and is completed in a period of about nine months, while in the human the period of growth may extend from fifteen to twenty years. He offers the hope that the ability to produce deformities by localized fusions may help overcome fixed deformities in the opposite direction.—*I. William Nachlas, M.D., Baltimore, Maryland.*

Bacillus Pyocyaneus Osteomyelitis of the Spine. Report of a Case of Successful Treatment with Sulfanilamide. Albert J. Schein. *Archives of Surgery,* XLI, 740, Sept. 1940.

Bacillus pyocyaneus osteomyelitis of the spine is probably very rare. Schein did not know of any cases described in the literature, and, therefore, reports a case that came under his observation.

He calls attention to the fact that occasionally this organism, which is generally only mildly pathogenic, becomes a dangerous invader, particularly after instrumentation of the genito-urinary tract. In the case described, pyocyaneus septicaemia followed a cystoscopic examination. Subsequently, an osteomyelitis of the spine developed and is believed to have been due to the pyocyaneus infection. Immobilization by a plaster

jacket, and sulfanilamide were used in treatment. Apparently the chemotherapy helped in the cure of the patient.—*I. William Nachlas, M.D., Baltimore, Maryland.*

ISCHEMIC CONTRACTURE OF THE LOWER EXTREMITY. Thomas Horwitz. *Archives of Surgery*, XLI, 945, Oct. 1940.

Through the medium of a report of two cases of ischaemic contracture involving the lower extremity, Horwitz calls attention to the fact that Volkmann's contracture can occur in the lower limbs as well as in the upper.

A review of the literature is included and would indicate that relatively few instances of this involvement have been recorded. The etiology is discussed with the apparent conclusion that a venous obstruction is responsible for this complication. Such obstructions could easily be produced in fractures of the lower part of the femur within the popliteal space, where the popliteal vein lies ventral to the soleus muscle, and near the junction of the anterior tibial vein with the posterior tibial vein between the two heads of the tibialis posterior. Though the clinical picture includes, in addition to muscular weakness and deformities of the foot, disturbances of sensation, it is believed that the neurological component is not an essential part of the syndrome. It is suggested that during the acute stage of the injury, which may lead to such complications, fasciotomy should be used. After the deformities have already developed, the usual orthopaedic procedures are helpful.—*I. William Nachlas, M.D., Baltimore, Maryland.*

USE OF THE THIERSCH SKIN GRAFT. B. K. Rank. *The British Medical Journal*, I, 846, 1940.

Statistics on 535 skin grafts, of which 391 were applied to surgically created surface wounds and 144 applied to unhealed or granulated areas, were given. In those applied to surgically treated wounds, a complete "take" was obtained in 83 per cent. In those applied to unhealed or granulated areas a complete take was obtained in only 41 per cent. In the latter group, sepsis was considered the outstanding cause of the poor results. In 72 per cent. of the grafts that failed to "take", sepsis was the cause. Hematomata were the cause of failure in 2 per cent.

Granulating areas are treated with hypertonic saline baths and ultra violet light, and special attention is given to the patient's general condition. In some the granulating surface is removed, and the results are apparently a little better when this is done. Grafts are carefully sutured to the entire wound and pressure dressings are applied. Dressings are not removed for at least seven days. He emphasizes that thinner grafts are more liable to take. Grafts take equally well on all regions except where absolute fixation and firm pressure cannot be obtained.—*Joseph G. Riley, M.D., Boston, Massachusetts.*

TUBERCULOSIS OF THE KNEE. A FOLLOW-UP INVESTIGATION OF OLD CASES. R. C. Murray. *The British Medical Journal*, II, 10, July 6, 1940.

The author reports that in 2,922 cases of bone and joint tuberculosis, knee tuberculosis was found in 11 per cent. of the cases. An investigation of 124 cases, picked at random from this 11 per cent., and all followed for at least five years, was made. Biopsy was not done on any of the cases, and the diagnosis was made purely on clinical evidence. Patients were divided into three groups and treated as follows: (1) Thirty-three with synovial involvement were treated conservatively with a Thomas splint, and 30 per cent. had a full range of motion at the time of collecting the statistics. (2) Seventy patients with focal articular involvement were treated first conservatively and then by excision. The results in this group of cases were ankylosis in 45 per cent. after arthrodesis and in 10 per cent. after conservative care, and the highest mortality,—21 per cent. (3) Seven patients had extra-articular involvement. Five of them healed without inva-

sion of the joint, but in two the joint was affected. One of the conclusions drawn is that "synovial tuberculosis progresses to definite bone changes in 45 per cent. of the cases".—*Joseph G. Riley, M.D., Boston, Massachusetts.*

THE RATIONALE OF COMPLETE IMMOBILIZATION IN TREATMENT OF INFECTED WOUNDS. J. Trueta and J. M. Barnes. *The British Medical Journal*, II, 46, July 13, 1940.

The article is a summary of the available literature dealing with the spread of infection in the body and points out: (1) Bacteria can travel very rapidly from recent wounds to the internal organs; (2) Absorption of bacteria is carried out by blood and lymph streams; and (3) Any measure that reduces the amount of lymph flowing through a limb greatly decreases the chances of absorption of bacteria or their products. It is pointed out that there is no lymph flow from the leg of an animal at rest. It is recommended that wounds be given a thorough excision of the dead or questionable tissue and then receive complete immobilization by means of a plaster cast, which is left on for a relatively long period of time. The conclusion is drawn that it seems best to leave the task of destroying bacteria to the human body.—*Joseph G. Riley, M.D., Boston, Massachusetts.*

MUSCULAR RHEUMATISM. LOCAL INJECTION TREATMENT AS A MEANS OF RAPID RESTORATION OF FUNCTION. Martin Button. *The British Medical Journal*, II, 183, August 10, 1940.

The author uses "muscular rheumatism" to mean stiff neck, lumbago, and "pseudosciatica". A preparation called "novutox" is used, but he believes that any 2-per-cent. mixture of novocain and adrenalin would be equally efficacious. A point at the center of the pain and tenderness is selected and an injection is made one-eighth of an inch beneath the surface of the fascia covering the affected muscle and 2 cubic centimeters are distributed in this area. Patients rest for an hour, and then resume full activity. Specific directions are given for the injection technique for acute and chronic types of non-traumatic rheumatism, as well as for the traumatic type, with illustrations of each type.—*Joseph G. Riley, M.D., Boston, Massachusetts.*

GOLD THERAPY IN RHEUMATOID ARTHRITIS. Philip Ellman; J. Stewart Lawrence; and G. P. Thorold. *The British Medical Journal*, II, 314, Sept. 7, 1940.

Ninety cases of rheumatoid arthritis were divided into three comparable groups. One group of patients were given large doses of gold weekly (.2 or .3 grams). The second group were given small doses (.1 gram) of gold weekly; and the third group, the control group, were given weekly injections of sterile almond oil. (The gold salt used was a British product, "solganal B", and the gold concentration is not given, so comparison with American products is not possible.) Results were judged on the basis of sedimentation rate, circumference of affected joints, clinical appearance of the joints, and roentgenograms. All cases were followed for at least nine months. In 77 per cent. of the group receiving large doses of gold, the sedimentation rate returned to normal. In the group receiving small doses only 37 per cent. became normal, and in the control group, 13 per cent. had a normal sedimentation rate at the end of the experiment. The other indicators of improvement paralleled the sedimentation-rate improvement. Toxic effects were more prevalent in the series receiving large doses, but only rarely were toxic effects seen before the sedimentation rate reached normal. No conclusion is reached concerning the most suitable dosage.—*Joseph G. Riley, M.D., Boston, Massachusetts.*

STUDIES IN EXPERIMENTAL SHOCK. C. H. Best and D. Y. Solandt. *The Canadian Medical Association Journal*, XLIII, 206, 1940.

At the outbreak of the war the authors' attention was directed to the still unsolved problem of traumatic shock, which is certainly one of the major difficulties faced by

military medicine Their interest has been chiefly in the treatment of the condition, and the present work was undertaken with a view to evaluating certain methods of treating shock in experimental animals They felt that any procedure useful in severe shock should be initiated by the administration of a vasoconstrictor, temporarily to correct vascular atony so that solutions introduced into the blood stream are not lost immediately into tissue spaces Concentrated blood serum was chosen for the restoration of blood volume, because it reduces tissue fluids and because it may be kept indefinitely without deterioration, and experimental results indicate that unless the blood pressure is very low pituitrin rather than epinephrine is the better vasoconstrictor to use preceding the administration of concentrated serum Pituitrin and concentrated serum yielded a relatively prolonged rise in blood pressure, such as was never seen under comparable conditions after the administration of either the concentrated serum or the vasoconstrictor alone The relative efficacy of serum and of whole blood is at present being determined The results leave no room for doubt that under the conditions of these experiments the deficiency is largely of protein and fluid rather than of red cells Their experiments indicate that in traumatic shock at least the injection of a hypertonic fluid is more beneficial than an isotonic one of the same constituents. In shock due to hemorrhage this is probably not true They believe that the results of these experiments on animals should encourage a further trial of concentrated human blood serum on patients suffering from shock. A project has been started for obtaining and processing large quantities of human blood serum. While the preparation is proceeding at a rather moderate rate, it can be stated that the organization is complete and that it can be readily enlarged in Toronto or duplicated in other centers in Canada, or elsewhere as required —*F. R Wilkinson, M D , Toronto, Ontario*

THE COMBINED SURGICAL AND FLUOROSCOPIC METHOD OF INSERTING THE SMITH-PETERSEN NAIL. George H. Ryan and Digby Wheeler. *The Canadian Medical Association Journal,* XLIII, 231, 1940

The authors have attempted to simplify the introduction of the Smith-Petersen nail in the treatment of fractures of the neck of the femur Their modification has been the use of a stab incision only, without guides, but with fluoroscopic control of the insertion of the guide wire and finally of the nail The examination of the femoral neck in the lateral view is made by flexing the thigh rather than by moving the tube, or even having a second tube available They are convinced that a fractured hip may be placed in full flexion without the slightest risk of the displacement recurring, provided that, while the thigh is brought up to 90 degrees' flexion, full internal rotation and full abduction are maintained Their average operating time for twenty-two cases has been ten and a half minutes —*F R Wilkinson, M D , Toronto, Ontario*

FIXATION OF DISLOCATIONS OF THE ACROMIOCLAVICULAR JOINT AND RUPTURE OF THE CORACOCLAVICULAR LIGAMENTS Gordon Murray. *The Canadian Medical Association Journal,* XLIII, 270, 1940.

Fresh dislocations of the acromioclavicular joint are easily reduced, but the strappings and bandages used to maintain the reduction are usually ineffective Applying the principle described in an earlier paper on fractures of the clavicle, the author's method is to reduce the dislocation of the acromioclavicular joint, and then pass one or two Kirschner wires through the acromion process across the acromioclavicular joint and into the outer third of the clavicle It was hoped that, if the joint was maintained in good position by these means, the ends of the ruptured ligaments would lie in apposition and would be in a position to unite and repair Five cases of this type have been treated in this way with successful results in all In most cases the wires were removed, as they necessarily passed through some fibers of the origin of the deltoid muscle, and consequently caused some discomfort on abduction of the shoulder The patients were able to move the arms

about quite freely immediately following the operation, and most of them returned to ordinary desk work within a few days without any other support. Two cases of recent wide dislocation with rupture of the coracoclavicular ligaments were treated with most satisfactory results. Roentgenograms taken later showed extensive calcification of the coracoclavicular ligaments, and gave strong confirmatory evidence that these ligaments had been torn and that they had become repaired. The attractive part of this method of fixation is the ease with which it can be carried out and its effectiveness. It supports the bones adequately and the patient has no discomfort. There is no deformity when the ligaments have become repaired, and there is no disability later on. None of these dislocations has recurred so far.—*F. R. Wilkinson, M.D., Toronto, Ontario.*

The Surgical Treatment of Flat Feet. Gerald L. Burke. *The Canadian Medical Association Journal*, XLIII, 327, 1940.

The author has recently completed a detailed survey of the end results in 110 patients operated upon for flat feet at the Los Angeles Orthopaedic Hospital. In the majority of these patients Young's modification of Lowman's operation has been done. Young performs a plastic lengthening of the tendo achillis as a preliminary procedure. A drill hole and slot are made vertically through the scaphoid and the tendon of tibialis anterior is pulled posteriorly and placed through the slot into the drill hole. After the operation long leg plaster casts are applied which are removed at the end of seven weeks.

The indications for operation are painful flat feet which have not improved under conservative treatment or which in the surgeon's judgment are unlikely to improve under conservative treatment. The author believes that in general there is a fundamental objection to the fusion of any joint in the surgical treatment of flat feet. The results of operation have been satisfactory to both patients and surgeons in more than 90 per cent. of the whole series.—*F. R. Wilkinson, M.D., Toronto, Ontario.*

A Contribution to the Anatomy of the Ulnar Bursa. C. R. Salsbury. *The Canadian Medical Association Journal*, XLIII, 430, 1940.

The author has carefully investigated the hands dissected in the anatomy laboratory during the past four years. He found that in 25 per cent. there is no normal communication between the ulnar bursa and the digital sheath of the little finger. In more than 50 per cent. the communication is small and valvelike. In the majority of hands showing no normal communication the two synovial sacs are separated only by a thin septum. Infection of the ulnar bursa is likely to reach the digital sheath by rupture of this membrane. It does not follow, however, that infections of the digital sheath can be easily spread to the ulnar bursa, because the valvelike arrangement of the pointed and invaginated distal end of this bursa may readily close the opening. It is suggested that the production of Kanavel's sign is related to the peculiar anatomical structure of this region.—*F. R. Wilkinson, M.D., Toronto, Ontario.*

Osteocondrosis de la Rama Isquiopubiana del Coxal (Osteochondrosis of the Ischiopubic Branch of the Hip Bone). Alberto Inclán. *Cirugía Ortopédica y Traumatologia* (Habana), VII, 99, 1939.

After commenting on the conception of osteochondrosis in general, the author reviews the literature of ischiopubic osteochondrosis. He has treated many cases of posttraumatic coxitis characterized by pain, claudication, and relative functional restriction of motion in the hip, the symptomatology of which disappears completely after two to three weeks of rest. Some of these cases had been diagnosed elsewhere as coxalgia or Perthes' disease, but the lasting disappearance of the symptoms after some days' rest, ensured the correct diagnosis of ischiopubic osteochondrosis of the growth period.

It was found in the study of 210 roentgenograms that the closure of the ischiopubic epiphyses was complete at the age of seven years, and not, as is pointed out in the textbooks of anatomy and in the medical literature, from eight to ten years. The findings of the roentgenograms are presented in a table. It was also found that in unilateral congenital dislocation of the hip, the closure of the epiphysis in the dislocated hip is delayed, probably due to hypoplasia, as was pointed out by Delitala.

The author stresses that it is necessary to know the course of ossification and its roentgenographic varieties in order to interpret correctly the typical pathological changes of ischiopubic osteochondrosis of the hip bone. In each of the three cases presented the author's criterion, that the bone structure of the ischiopubic branches is altered only when there is some pathological condition at this level, is fully supported. They also show the difficulty of differential diagnosis between this type of osteochondrosis and an inflammatory or infectious pelvic or coxofemoral affection without an x-ray examination.

Though the author does not wish to make any definite statement regarding the etiology of the disease, he believes that trauma is the most frequent source of osteochondritis and osteochondrosis. As in other locations, ischiopubic osteochondrosis is benign, and a cure without deformity is soon obtained by rest and immobilization. The closure of the epiphysis always produces a permanent cure in this form of osteochondrosis.

Radiculalgias Rebeldes en Ortopedia (Persistent Radicular Pain in Orthopaedic Conditions). A. Barbí Inclán. *Cirugía Ortopedica y Traumatología* (Habana), VII, 121, 1939.

The author presents some observations on persistent radicular pain, or, as its name implies, pain from the spinal nerve roots, due to irritation, compression, or inflammation.

The steadily increasing frequency of this syndrome, its diagnostic as well as prognostic difficulties, its varied and sometimes dangerous treatment, and the infrequency of its incidence in his country, have induced the author to describe four clinical cases treated by him in the National Police Hospital. Three patients had low or sacrolumbar nerve-root pain, and one had pain in the cervical region.

The three cases with low-back pain presented some degree of scoliosis with radiation to the sciatic nerve; one was syphilitic (arachnoiditis), another rheumatic with an evident spondylitis and presumably, also, arachnoiditis, while the third had suffered a traumatic lesion, followed by hypertrophy of the transverse apophysis of the fifth lumbar vertebra and sacro-iliac subluxation.

The fourth case, with radicular pain in the cervical region, presented what appeared to be an infectious arthritis with a possible focus of infection in the vertebrae, but without bone lesions visible in the roentgenograms.

Conservative treatment was employed in all four cases. Besides continuous traction and strict immobilization, medical treatment—injections of patogenol gardier, and the use of salycilate, iodin, sulphur—physiotherapy, and hydrotherapy were also employed. Corrective manipulation without anaesthesia was carried out in the patient with posttraumatic radicular pain.

A great many laboratory tests were carried out. In three cases, the x-ray examination was preceded by a lipiodol injection into the spinal canal.

Though all the patients at present appear cured, there is no assurance that the symptoms will not recur.

Artropneumorradiografia de la Rodilla (Arthropneumoradiography of the Knee). J. I. Tarafa. *Cirugía Ortopédica y Traumatología* (Habana), VIII, 3, 1940.

The injection of contrast media into the joints is indicated in those cases, where an examination of the soft parts within the joint—menisci, capsule, or cruciate ligaments—is desired as well as in the search for foreign bodies, tumors, or other intra-articular changes.

If the meniscus is detached the arthropneumoradiogram will show the penetration of air between the tibial plate and the meniscus; if the meniscus is ruptured the arthropneumoradiogram will show more or less irregular interruptions at the site of the rupture. Tearing off of the cruciate ligaments produces some changes in the normal picture, and is often associated with fracture of the tibial spine. In arthritis there is an enlargement of the capsule and irregularities in its walls. Intra-articular tumors show perfectly defined outlines, while the extra-articular variety squeeze and displace the capsule. Loose bodies in the joint are more clearly seen. In Charcot's knee, besides a marked increase of the joint space and abnormal features of the joint surface, an almost complete destruction of the soft parts is visible.

A Case of Untreated Traumatic Spondylolisthesis of the Third Cervical Vertebra. M. G. Kini and P. Kesavaswami. *The Indian Medical Gazette,* LXXIV, 748, 1939.

The authors report a case of fracture-dislocation of the third cervical vertebra in a man, forty-five years old, who refused surgical treatment. The injury was the result of a fall from a rocking chair when it rocked back too far. The paralysis often associated with such a fracture-dislocation did not occur, and the man complained only of slight rigidity. Roentgenographic examination showed that the body of the third cervical vertebra had slipped forward and the lamina, which was fractured from the body, had remained *in situ.* The case resembled spondylolisthesis due to trauma.

Rôle of Oblique Osteotomy of Upper End of Femur in Hip Joint Surgery. M. G. Kini. *The Indian Medical Gazette,* LXXV, 257, May 1940.

In this article the author discusses derangement of the hip joint, whether due to congenital, traumatic, or pathological causes, and its effect on both locomotion and stability. He tells of his experience with the Lorenz bifurcation in a number of cases, including congenital dislocation, old ununited fractures of the neck of the femur, pathological dislocations of the hip, and osteo-arthritis of the hip. Several of the cases are illustrated by photographs and tracings of roentgenograms. His follow-up of cases in which the oblique osteotomy was performed has convinced the author of the usefulness of this operation.

Plaster-of-Paris. G. R. Girdlestone. *The Lancet,* II, 287, Sept. 7, 1940.

The writer gives clear and concise instruction in the use of plaster-of-Paris. In addition to outlining the proper methods for applying plaster bandage, he describes the cream-fabric method advocated by Trueta for the rapid application of plaster fixation. The pen-and-ink illustrations are helpful, and the article should be invaluable in the training of military surgeons.—*Lenox D. Baker, M.D., Durham, North Carolina.*

Treatment of War Wounds of the Limbs. Experience in 266 Cases. Solly M. Cohen and C. A. R. Schulenburg. *The Lancet,* II, 351, Sept. 21, 1940.

The authors review their experience in assisting with the care of the wounded in the evacuation from Dunkirk and assess the value and dangers of different methods of treatment. All the patients had been wounded at least twenty-four hours earlier and therefore came under the category of "late" cases. The authors condemn the use of local anaesthesia, having found that evipan or pentothal, followed by gas and oxygen, was most satisfactory.

The wound was thoroughly cleansed with ether, soap, and saline. No antiseptics were used. Skin edges were excised, and the wound was laid wide open by radiating incisions without needless sacrifice of skin. Great attention was paid to the fascia as it was

found that, although there was only a small hole in the fascia, there was often extensive disruption of the deeper tissue. To allow adequate drainage, relaxation of the fascia was necessary and was obtained by radiating incisions. No attempt was made to excise or trim muscle or to suture nerves or tendons though the frayed ends of the latter were removed. Only detached fragments of bone were removed. All cases were x-rayed before operation. Large splinters of foreign material were always removed, but no attempt was made to remove the small splinters lying some distance from the entry wound. Subsequently, in a few cases, localized abscess formation around a foreign body necessitated incision. The principle of counter incisions was employed when indicated. Petroleum-jelly gauze from two-inch rolls was used throughout for packing every recess and intermuscular plane. The surrounding skin was coated with a thick layer of petroleum jelly to prevent dermatitis and excoriation. The authors used the closed-plaster method, applying the cast next the skin except for a thin layer of sterilized plaster wool over the wound. Windowing the cast is counselled against because of the development of "window oedema". No prophylactic anti-gas-gangrene serum was given and there was no case of true gas gangrene.

The authors state that the healing of these wounds treated in plaster was astonishing; and they feel that the value of the closed plaster method both for fractures and injuries of the soft tissues is confirmed. The article is well illustrated and the authors' proficiency in the use of plaster-of-Paris is attested to by the photographs.—*Lenox D. Baker, M.D., Durham, North Carolina.*

An Operation for Ankylosing the Knee Joint. N. D. Royle. *The Medical Journal of Australia*, I, 110, Mar. 23, 1940.

The author states that he has performed this operation in cases of paralytic flail knee for fifteen years and has not had a failure.

The skin and capsular structures are opened by a U incision, the base of which crosses the patella tendon. This is severed, and the patella laid upward. The tibial and femoral surfaces are denuded of cartilage by horizontal sections which give approximation of raw bone surfaces. A vertical anterior sliding graft is then cut from both bones, the longer femoral portion being slid down into the tibia and the shorter tibial portion being placed in the resulting defect in the femur. Union occurs after twelve weeks in plaster, but a knee splint is worn for three more months.

No case reports or statistics are given other than the statement in the first paragraph.—*John D. Blair, M.D., Iowa City, Iowa.*

Morton's Metatarsalgia: Neuritis of the Fourth Digital Nerve. L. O. Betts. *The Medical Journal of Australia*, I, 514, Apr. 13, 1940.

The author gives evidence in this article to support his belief that Morton's metatarsalgia is a neuritis of the fourth digital nerve, with a pronounced neuroma in all cases. He and his colleagues have had nineteen such cases, in all of which the fourth digital nerve was involved, with a definite neuroma in each.

The author postulates the theory that the condition is due to the double origin of the fourth nerve. It is formed by a joining of branches from the external and internal plantar nerves, which come from opposite sides of the belly of the flexor brevis, the nerve thus formed passes forward immediately on the transverse ligament. When the foot is in action the flexor brevis contracts, fixing the origin of the nerve, while dorsiflexion of the toe in walking stretches it around the unyielding transverse ligament. Each of the other digital nerves can slide easily longitudinally as the toes are dorsiflexed. A minor trauma causes the neuritis which progresses because of continued daily irritation.

The author treats the condition by a neurectomy, removing the neuroma and an inch of the nerve through a longitudinal incision between the heads of the third and fourth metatarsals.—*John D. Blair, M.D., Iowa City, Iowa.*

SENILE OSTEOPOROSIS. Ernst Lyon. *Radiologia Clinica*, IX, 89, 1940.

In a discussion of senile osteoporosis, the author states that this disease develops in the entire osseous system, but becomes most evident in the spinal column. The clinical symptoms are lumbago, backache, stitches in the thoracic sides and legs, weakness and exhaustion, decrease in body length, kyphoscoliosis, spontaneous fractures, and bone sensitiveness. Senile osteoporosis develops when bone apposition ceases, while decomposition is normal or increased. The etiological factors consist of polyglandular disturbances, polyhypovitaminosis, heredity, and diet. Consideration should be given to disturbance of liver function in its capacity of transforming provitamin (carotene) into vitamin A. The vitamin-A deficiency in its turn produces osteoporosis. The diagnosis must be differentiated from tuberculosis, osteomalacia, von Recklinghausen's disease, and non-tropical sprue. Treatment consists of the use of vitamins A and D, calcium, thereafter mechanical support for the spinal column; and deep irradiation if hypophysial disturbance is considered an exciting cause.—*Frederic W. Ilfeld, M.D., Los Angeles, California.*

LA NECESSITÉ D'HÔPITAUX SPÉCIAUX POUR LES MALADES DE TUBERCULOSE DES OS ET DES ARTICULATIONS (THE NEED FOR HOSPITALS ESPECIALLY EQUIPPED FOR THE TREATMENT OF CASES OF TUBERCULOUS BONES AND JOINTS). Bruno Valentin. *Revista Brasileira de Cirurgia*, February 1939.

The author discusses the need for hospitals especially equipped for the treatment of patients suffering from tuberculosis of the bones and joints. He considers the matter from both practical and theoretical viewpoints, but he stresses chiefly the requirement for special medical care. These patients should be regarded in a category entirely different from the ordinary surgical cases in which the hospital stay is brief, for treatment must be continued for months or years and cannot be accomplished in a general hospital unless there is a department with adequate equipment and facilities for special surgical attention and nursing.

Dr. Valentin considers the effect upon the individual of long continued treatment and the psychological aid which may be rendered by proper surroundings. He cites the value of heliotherapy treatment and discusses the conditions which are found at high altitudes and at the seashore. He also quotes authorities who have realized that special departments should be provided, with modern appliances, and urges that these patients be cared for by those who have had special training in the treatment of bones and joints.

MALFORMATIONS DU SYSTÈME DE L'APPAREIL LOCOMOTEUR (DEFORMITIES OF THE LOCOMOTOR SYSTEM). Bruno Valentin. *Revista Brasileira de Cirurgia*, July 1939.

In classifying deformities, the author states that distinction should be made between a syndrome, deformity of a system (muscles, nerves, etc.), and hereditary deformities. He gives illustrations of cases which have come under his observation, arachnodactylia, cleidocranial dysostosis, pleonosteosis familiaris (Léri), melorheostosis (Léri), and other conditions in which the entire system is involved. In his discussion of each he includes the clinical picture, the hereditary factors, and the still very obscure pathogenesis. Until recently little has been known of the etiology of the diseases mentioned.

ALGUMAS RELAÇÕES ENTRE DOENÇAS DO SISTEMA OSSEO E AS GLANDULAS ENDÓCRINAS (RELATIONSHIPS BETWEEN THE OSSEOUS SYSTEM AND THE ENDOCRINE GLANDS). Bruno Valentin. *Revista Brasileira de Cirurgia*, December 1939.

The author demonstrates that it is not always possible to differentiate disturbances of the glands from their relation to the skeletal system, for the functions of the endocrine glands depend upon the brain which also controls the development of the extremities. He then describes congenital and acquired affections of bones associated with functional

disturbance of the endocrine glands. Hypogenitalism or hypergenitalism may also be a complication in these cases.

From many observations at his clinic, the author arrives at the conclusion that it is not always possible to decide whether a certain affection has its origin in the brain, the glands, or the bones.

DESCOLAMENTO TRAUMATICO DA EPIPHYSE INFERIOR DO FEMUR (Traumatic Slipping of the Inferior Femoral Epiphysis). Domingos Define. *Revista Brasileira de Orthopedia e Traumatologia*, I, 277, Mar.–Apr. 1940.

The author describes two cases of traumatic slipping of the lower femoral epiphysis with lateral displacement. A statistical analysis of this type of trauma is presented together with a description of the mechanism producing it. An immediate reduction either by open or closed method followed by immobilization is advised.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

SOBRE A FRACTURA ISOLADA DA APOPHYSE EXTERNA DO ASTRAGALO (On an Isolated Fracture of the External Apophysis of the Talus). Achilles de Araujo. *Revista Brasileira de Orthopedia e Traumatologia*, I, 311, Mar.–Apr. 1940.

The author, who found only two recorded cases of this type in the literature, describes his case in detail and gives an analysis of the producing mechanism. The symptomatology of the lesion was pain just below the external malleolus and above the external tubercule of the calcaneum, crepitation at the same level, and fixation of the foot in equinovarus. The treatment consisted in reduction under local anaesthesia, immobilization in plaster-of-Paris for one month, and physiotherapy.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

MEGALODACTYLIAS E MEGALOSYNDACTYLIAS (Megalodactylism and Megalosyndactylism). Achilles de Araujo, *Revista Brasileira de Orthopedia e Traumatologia*, I, 341, May–June 1940.

The author describes a very interesting clinical case of a pregnant woman with a fibroma of the body of the uterus, who gave birth to a boy with a megalosyndactylism of the second and third toes of the right foot. Roentgenograms taken at the eighth month, to clear up the differential diagnosis of twin pregnancy or tumor, showed the anomaly. The observation of the case of megalosyndactylism which ended with a metatarsophalangeal disarticulation is described at length. The author justifies his preference for the term megalosyndactylism instead of macrosyndactylism and describes two personal cases of megalosyndactylism. He gives some consideration to the etiology of such unusual anomalies with special reference to megalosyndactylism.—*Azzi Leal, M.D., São Paulo, Brazil.*

CONSIDERACÕES SOBRE FRACTURAS DA RACHE (Vertebral Fractures). E. Guilherme, *Revista Brasileira de Orthopedia e Traumatologia*, I, 369, May–June 1940.

The author refers to statistics organized by one of his collaborators (Milton Weimberg), which include fractures of the spine observed from the years 1933 to 1936 at the Hospital do Prompto Soccorrodo Rio de Janeiro (Emergency Hospital of Rio), of which the author was the organizer and chief. He considers the spinal fractures from various interesting aspects, among which is that of the careful transportation of patients, every one of whom should be considered, from the practical viewpoint, a latent paraplegic. Dividing the fractures of the vertebral column into two groups, those in which the fractures affect only the bone portions, and those in which there is laceration of the medula as well, the author discusses their treatment and gives some indispensable directions for obtaining the best results from the adopted therapeutic means.—*Azzi Leal, M.D., São Paulo, Brazil.*

FRACTURA MARGINAL POSTERIOR DO PLANALTO TIBIAL (Posterior Marginal Fracture of the Tibial Plateau). Correa do Lago, Jr. *Revista Brasileira de Orthopedia e Traumatologia*, I, 375, May–June 1940.

One case is described, the interest of the description lies in the anatomical and mechanical study of the lesion which is explained by indirect avulsion of the fragment through the cruciate ligament.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

OSTEOMIELITIS CRÓNICA DEL ESTERNÓN; ABSCESO MEDIASTINAL PREPERICÁRDICO, POSTOPERATORIO. CURACIÓN (Chronic Osteomyelitis of the Sternum; Postoperative Prepericardial Mediastinal Abscess. Case with Recovery). Carlos I. Allende, and José P. Traverso. *La Revista de Medicina y Ciencias Afines*, I, 34, 1939.

Osteomyelitis of the sternum is very rare and quite serious, the mortality being nearly 50 per cent. The reason for the high mortality is the fact that a mediastinal infection frequently accompanies the osteomyelitis. The authors present a case in a woman aged twenty nine years. She had had a fistula of the sternum for ten years which developed gradually. Her presenting symptom was the presence of lumps in the region of both breasts which were felt to be lymph glands. A diagnosis of osteomyelitis of the sternum was made and the patient was operated upon. The operative wound did not heal completely and a small sinus formed which made it necessary to perform an additional operation. At this time a retrosternal prepericardial abscess was encountered and drained. Following this the abscess cavity closed up and stopped draining, and the osteomyelitis cleared up completely, leaving the patient entirely well. A general discussion concerning the pathology, differential diagnosis, and treatment of osteomyelitis of the sternum is given. The article is well illustrated with roentgenograms which show the osteomyelitis of the sternum, and the retrosternal abscess which was visualized by the injection of lipiodol.—*Louis W. Breck, M.D., El Paso, Texas.*

LA OSTEOSÍNTESIS EN LAS FRACTURAS ABIERTAS (Internal Fixation in Open Fractures). R. Paterson-Toledo. *La Revista de Medicina y Ciencias Afines*, I, 44, 1939.

This is a rather academic discussion of operative versus non-operative treatment of fractures and especially of compound, infected fractures. The discussion opens with the presentation of two axioms: Reduction should be anatomically exact, and immobilization should be absolute. Opinions vary considerably as to the importance of anatomical reduction. The English committee for the study of fractures found that 92 per cent. of fractures with good results had exact anatomical reposition, and the author lays great stress on the importance of anatomical reposition. Open reduction is the most certain and satisfactory way of obtaining an anatomically perfect result, and of being sure of complete fixation. On the other hand he points out that many people are opposed to open reduction and prefer closed reduction at all costs. Other forms of treatment such as continuous traction, double-fixed skeletal traction, etc., are used in order to avoid an open reduction. He mentions the advantages and disadvantages of each of these methods. The French school, headed by Lambotte, is quite radical in general, and its members believe that open reduction should be performed in fractures of the shaft of the long bones if there is any doubt about holding the fracture in good anatomical position. Verbugge of Belgium is of practically the same opinion. The Europeans lay great stress on exact anatomical reposition and feel that by obtaining it wound healing in infected fractures is greatly accelerated. The author, after going into considerable detail in the discussion of these methods, states that in his opinion many of the very good statistics concerning open reduction in infected fractures do not stand close scrutiny. He feels that generally speaking it is too dangerous to perform open reductions on already infected fractures and that conservative orthopaedic measures in general will be attended with satisfactory results and a lower mortality.—*Louis W. Breck, M.D., El Paso, Texas.*

RÉSULTATS ÉLOIGNÉS DES MÉNISCECTOMIES (Late Results of Meniscectomies). Vandendorp, Bastien, et Vandecasteele. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur,* XXVI, 629, 1939–1940.

The authors review sixty-one meniscectomies, of which three were for cysts of the meniscus and fifty-eight for trauma, from the clinic of Prof. O. Lambret of Lille.

There are difficulties in the proper estimation of late results. If postoperative motion of the knee is considered alone, the late results may give an inaccurate percentage of improvement. It is important to ascertain the amount of residual pain at rest, standing, running, jumping, and kneeling,—activities which are important in certain professions. Two types of operations were used for injuries: the usual parapatellar incision in forty-four cases, and the method of Tavernier, consisting in a horizontal arthrotomy with complete section of the collateral ligament, in fourteen. The postoperative care consisted in a posterior splint for eight days, with walking on the twelfth day in the first type, and a posterior splint for fifteen days with walking on the twentieth day in the Tavernier operation. Of all the cases operated on, estimation of late results could be made in forty-nine, only. Of these a restitution and integrum was obtained in 22 5 per cent., eleven cases; excellent results, consisting in excellent function and absence of pain, except for some pain observed on change of weather, in 42.5 per cent., twenty-one cases; good results—good function but accompanied by pain, especially on kneeling—in 24.5 per cent , twelve cases; mediocre results with limitation of extension and flexion and increased lateral mobility in 10.5 per cent., five cases. Of the twelve observed postoperative results of Tavernier's meniscectomies, two gave complete restitution, five excellent, two good, and three mediocre results. The authors express the view that the results show that the two types of operation are of equal value.

An x-ray study of the postoperative results revealed that the late appearance of deforming arthritis is insignificant, and that the mild articular changes due to the absence of the meniscus are of no practical importance.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

L'OSTÉOCHONDRITE DISSÉQUANTE (Osteochondritis Dissecans). Pierre Ingelrans and E. Laine. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur,* XXVI, 645, 1939–1940.

The authors present a short study of the entire problem with an illustrative case report. They advise surgical treatment. In their discussion on the pathogenesis of osteochondritis dissecans, they propose a new theory. Policard has shown that the synovial membrane has the property of cytolysis. It may then be responsible for a separation of a fragment from the surface of bone which undergoes changes of any sort. The elective localization of osteochondritis dissecans in areas which are covered with synovia, the absence of these lesions in areas deprived of the synovial membrane, and, finally, the structure of the deep layer of the foreign bodies, which is very similar to the synovia, all speak in favor of this theory.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

LE TRAITEMENT DES FRACTURES DE GUERRE PAR L'APPAREIL PLATRÉ OCCLUSIF (The Treatment of War Fractures with Closed Plaster-of-Paris Apparatus). G. Baillat. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur,* XXVI, 656, 1939–1940.

The author bases his experience mostly on the war casualties in the Spanish war, which were treated in southern France. The urgent and calamitous evacuation of the wounded soldiers and civilians did not permit a proper appreciation of the methods used. Those wounded, who were treated according to the strict rules, as proposed by Trueta, showed remarkable results.

The author describes the principles of treatment of Trueta of Barcelona and the various theories of the mechanics of healing by the closed-plaster method. Like Trueta, the author does not use the preliminary vaselin dressing, as advised by Orr. He con-

Untersuchungen zur Morphologie der Kniegelenksmenisci an Hand von Messungen und histologischen Befunden (Morphology of the Menisci of the Knee on the Basis of Measurements and Histologic Findings). G. Schallock. *Virchows Archiv für pathologische Anatomie,* CCCIV, 559, 1939.

The author examined the tendency of slipping of the menisci, in relation to the length, cross section and weight of the meniscus, and finally he tried to find the variation in the histological picture of the menisci. All the measures mentioned were taken into consideration in relationship to the height and weight of the patient. He found that the height and weight of the menisci are proportionate to the height and weight of the patient. Weight-bearing, exceeding the normal duration, leads to changes in the proportions of the menisci. Weight-bearing causes an increase in length and non-weight-bearing causes an increase in width of the mensici.

Fatty and mucous degeneration due to pathological processes have nothing to do with normal conditions.—*T. J. Greteman, M.D., Iowa City, Iowa.*

Alte Brüche des Naviculare carpi (Old Fractures of the Carpal Scaphoid). Hans Virchow. *Virchows Archiv für pathologische Anatomie,* CCCV, 108, 1939.

1. The scaphoid (navicular) consists of two parts, the body and the cones, the latter being distal to the former.
2. The scaphoid has four articulating surfaces: (a) radial, (b) lunar, (c) capitate, and (d) multangular.
3. The cones are covered by periosteum except that part which articulates with the greater multangular. The surfaces between the articulation with the radius and the one with the greater multangular are without cartilage. Dorsiflexion of the hand is accompanied by dorsiflexion of the scaphoid.
4. The kinds of fracture are: (a) fracture of the cones, (b) comminuted fracture, and (c) oblique fracture.
5. The formation of a bone cavity is not the consequence of fracture, but is part of the fracture line which became atrophic.
6. There is a superficial bony plate which after a while bridges the fracture line and covers the marrow cavity.
7. Friction surfaces demonstrate that only flexion motion could take place after the injury.
8. Pseudoarthrosis is possible in any kind of fracture.—

T. J. Greteman, M.D., Iowa City, Iowa.

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Bulletin of the Hospital for Joint Diseases (New York), I, No. 3, October 1940.
The Child (Washington, D. C.), Index to Vol. IV, July 1939–June 1940; Vol. V Nos. 3 and 4, 1940.
Cleveland Clinic Quarterly, VII, No. 4, 1940.
Current Medicine (Los Angeles, Californai), VII, No. 10, 1940.
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The Journal of Bone and Joint Surgery

FRACTURES IN THE NECK OF THE FEMUR IN CHILDREN WITH PARTICULAR REFERENCE TO ASEPTIC NECROSIS *

BY BRANDON CARRELL, M.D., AND W. B. CARRELL, M.D., DALLAS, TEXAS

Fracture of the femoral neck in children, though a rare injury, frequently results in permanent disability. The characteristic site is at the cervicotrochanteric junction, and the most common cause is severe trauma received by falling from high elevations. Satisfactory reduction has been more difficult to secure and retain in children than in adults by the same commonly employed methods of treatment. Finally the incidence of aseptic necrosis is probably higher than in fractures of the neck of the femur in adults.

In this study of twelve such fractures in ten children the authors conclude that reduction with application of the Whitman abduction plaster is inadequate; nailing is undesirable; and traction alone does not correct the deformity. Traction and abduction combined not only reduce the fracture accurately, but maintain it satisfactorily. The location of the fracture in the cervicotrochanteric region is a favorable site for circulatory damage and aseptic necrosis.

A summary of this group, with regard to location of the fracture, shows eight of the cervicotrochanteric type and four of the mid-cervical type. Each of the latter four cases had some complicating factor relating to the injury.

Of the several methods employed for reduction and maintenance, manipulation followed by limited or full abduction in plaster was used in four cases of cervicotrochanteric fractures with poor results, and in two mid-cervical fractures with good results. The Hoke-type plaster with well-leg countertraction was used late in one case and was not successful. Had the adductors been tenotomized and the leg placed in wide abduction, the method would probably have succeeded, even though applied twenty

* Read before the Section of Bone and Joint Surgery of the American Medical Association, New York, N. Y., June 10, 1940.

FIG. 1-A

Case 1 Roentgenogram taken February 8, 1926, twelve months after cervicotrochanteric fracture. There has been increasing lameness for three months. Aseptic necrosis is well marked.

FIG. 1-B

Case 1. Roentgenogram taken March 18, 1927.

days after injury (Case 3). Abduction with traction was applied primarily in four instances and gave excellent results. In another case abduction with traction was applied with satisfactory results two weeks following injury, because of recurrence of the deformity (Case 4). A total of five fractures were reduced anatomically and held until union was complete by the method of abduction and traction. There was some variation in the method for securing abduction and traction in this group of four cases and five hips, but equally good results were obtained. In Case 1, Buck's extension with considerable weight, and elevation of the foot of the bed for six weeks, was used. In Case 4 the deformity recurred with the leg in plaster in fair abduction. Two weeks later a new plaster was applied which included both legs with wider abduction, skeletal traction through the lower end of the femur, and direct pull with weight for five or six weeks. Excellent position was secured, though aseptic necrosis later developed. In Case 10, a Jones splint was applied with skeletal fixation on the injured side. A Roger Anderson splint should be as effective. In Case 9, which was a bilateral one, fixed traction in wide abduction was used. Reduction was secured by table traction and abduction. Adductor muscles were then very tight and were tenotomized. A Kirschner wire was placed through the lower end of each femur and double spicas applied. It is probable that the fixed traction in abduction without adductor tenotomy would have been adequate, but with the high incidence

Fig. 1-C

Case 1. Roentgenogram taken fifteen years after injury. Patient has a slight limp but free motion and no pain.

FIG. 2-A

Case 3. Roentgenogram taken December 30, 1933, three weeks after injury, shows Hoke traction applied. Note distraction at the joint.

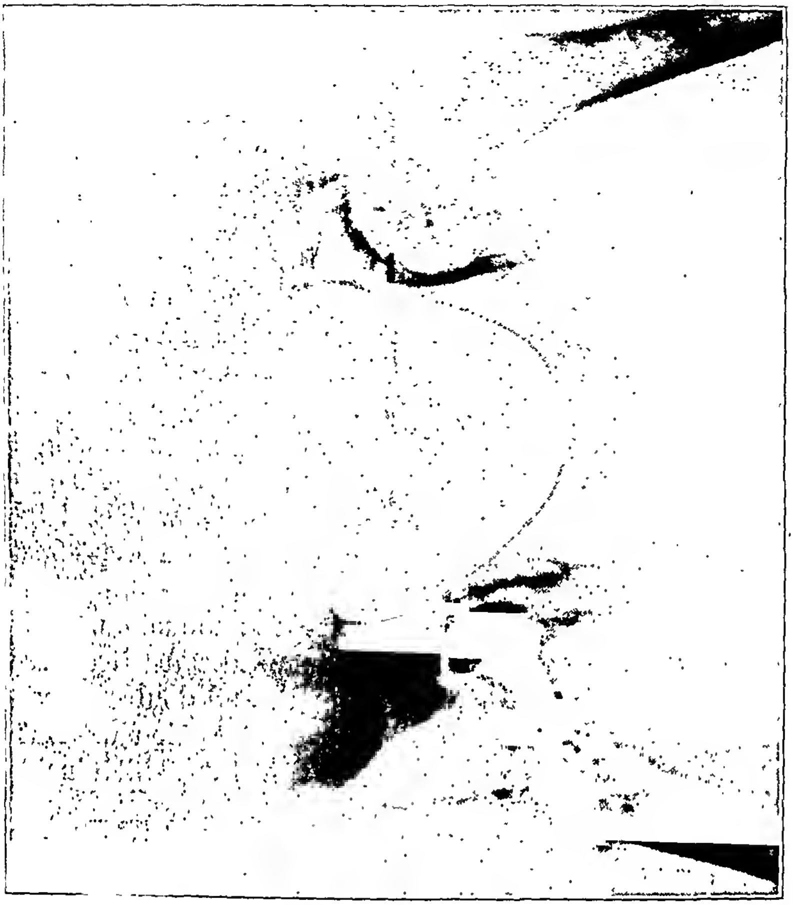

FIG. 2-B

Case 3. Roentgenogram taken January 30, 1934, shows open reduction and pin fixation.

FIG. 2-C

Case 3. Roentgenogram taken April 4, 1934, shows aseptic necrosis.

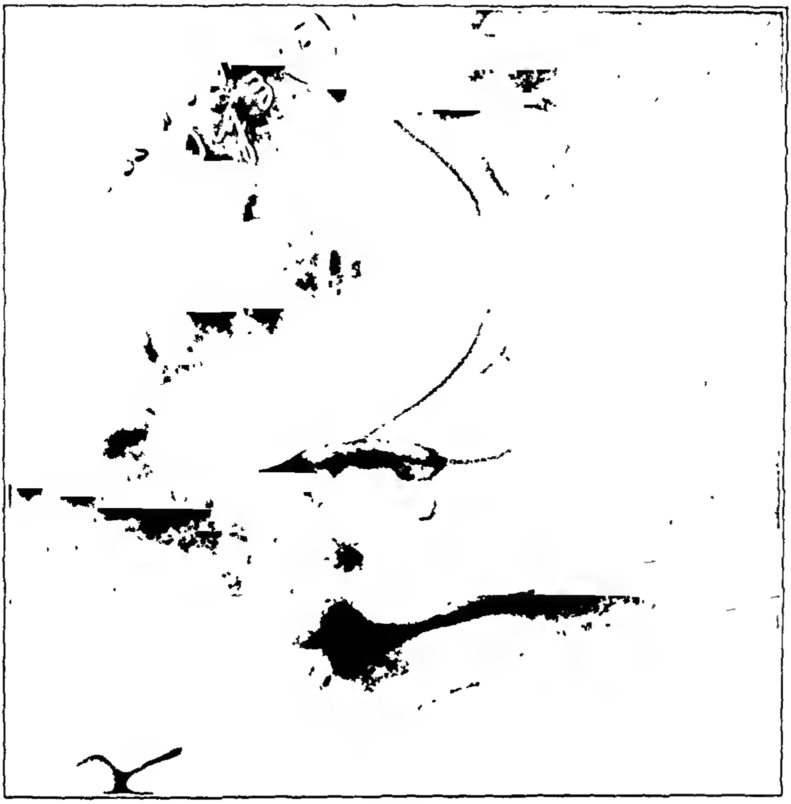

FIG. 2-D

Case 3. Roentgenogram taken October 25, 1935. Patient has instability and a painful limp.

of recurrence into deformity we would employ the same technique in another bilateral case. Convalescence was not appreciably affected by weakness in adduction.

Of the three patients who had open reduction, one, with fixation by a Smith-Petersen nail, had a successful result; in one, pin fixation was a failure because of aseptic necrosis; and one, with no fixation by internal device, had a very poor result.

In this group of twelve fractures, eleven were treated and the end result, regardless of complications, was good in seven, fair in two, and poor in two. Two in the group recorded "good" have been followed less than one year and aseptic necrosis may yet occur and alter the results. There was only one definite non-union and this was complicated by aseptic necrosis.

It [illegible] apparent that two major problems are encountered in treating these [illegible]. It is believed that the first, relating to reduction and retention [illegible] cervicotrochanteric type, has been solved by application of traction [illegible] abduction. Successful reduction can be accomplished in combi[illegible]h plaster to permit early discharge from the hospital. The mid-c[illegible] fractures may be treated by abduction and internal rotation, or, if n[illegible] nail or pin fixation, though consideration must be given to prem[illegible] closure of the epiphysis in the latter method. In patients with a deform[illegible] which has existed longer than four or five weeks, the fracture should b[illegible] [illegible]ted to unite, and later a corrective osteotomy may be perform[illegible].

Fig. 3-A

Case 4. Roentgenogram taken May 24, 1936, shows typical cervicotrochanteric type of fracture, which was treated in plaster for two weeks, and then by skeletal traction in abduction.

Fig 3-B

Case 4 Roentgenogram taken July 23, 1936. Note increased density in the neck

Fig 3-C

Case 4 Roentgenogram taken October 9, 1936. Patient has good union, slight limp, and no pain.

TABLE I

RÉSUMÉ OF TEN PATIENTS WITH TWELVE FRACTURES OF THE FEMUR

Case	Sex	Age	Type of Fracture	Treatment	Reduction	Secondary Plan	Reduction	Union	Coxa Vara	Aseptic Necrosis	Result
1*	F	9	Cervicotrochanteric, right	Reduction, traction in abduction. Buck's extension with foot of bed elevated for six weeks	Yes			Yes	No	Yes	Fair, 15 years
2	F	11	Cervicotrochanteric, right	Reduction and plaster	No	Open reduction after six weeks	No	No	Yes	Yes	Poor, 10 years
3*	F	5	Cervicotrochanteric, right	Reduction and plaster	No	Open reduction after four weeks	Yes	Yes	Yes	Yes	Poor, 7 years
4*	M	11	Cervicotrochanteric, left	Reduction and plaster	No	Reduction, traction in abduction	Yes	Yes	No	Yes	Fair, 4 years
5	F	8	Cervicotrochanteric, right	Reduction and plaster	No	After four days second reduction and plaster	Yes	Yes	30 degrees	No	Good, 2 years
6†	F	14	*Mid-cervical, bilateral*	*Reduction and plaster* for both hips	Yes			Yes	No	No	Good, both hips, 18 months
7	M	15	Mid-cervical, left	None	Poor	Fused hip	Crutches	Yes	Yes	No	Good for fused hip, 1 year
8	M	11	Mid-cervical, right	Smith-Petersen nail	Yes			Yes	No	No	Good, 16 months
9*	M	8	Cervicotrochanteric, bilateral	Reduction, traction in abduction, tenotomy of tight adductors, skeletal fixed traction for eight weeks	Yes			Yes	No	No	Good, bilateral, 18 months
10*	M	8	Cervicotrochanteric, left	Reduction, traction in abduction	Yes			Yes	No	No	Good, 13 months

* Cases illustrated in the text.

† A spastic child wearing thigh-length braces fell to the floor and fractured one hip. One year later she again fell and fractured the other hip.

Fig. 3-D

Case 4. [illegible] December 29, 1937, four months after weight-bearing. [illegible] limitation of motion, but no pain. Localized aseptic necrosis is present.

Fig 3-E

Case 4. Roentgenogram taken March 5, 1940, four years after injury, shows no clinical change.

ASEPTIC NECROSIS

The second problem is aseptic necrosis. This may occur regardless of treatment, but results may be favorably altered by avoiding vigorous

Fig 4-A

Case 9 Roentgenogram taken September 2, 1939, shows bilateral fracture. The patient fell twenty-five feet from a tree.

Fig. 4-B

Case 9. Roentgenogram taken November 16, 1939, after treatment by adductor tenotomy, abduction in plaster with skeletal fixation by wires at the lower end of the femora.

Fig. 4-C

Case 9. Roentgenogram taken February 22, 1940. Function was good for this date.

Note: Eighteen months after injury there was no evidence of aseptic necrosis, and function was good.

manipulation in primary reduction and by a long period of freedom from weight-bearing.

Because of the high incidence (33.3 per cent.) of this complication in the authors' series, several roentgenograms are reproduced which may be interpreted in relation to the circulatory mechanism in the femoral head of children.

Wolcott has shown, by injections of opaque materials, a pattern of anastomosis in the hips of children up to ten or thirteen years of age, which differs from that found regularly in 80 per cent. of adult hips.

In adults he finds that the capsular vessels enter, in two groups of three or four branches each, at the posterosuperior and postero-inferior juncture of the cervicotrochanteric region. They may traverse the loose capsular tissue to enter obliquely at the base of the head, and anastomose with the branches from the nutrient and the ligamentum teres vessels. In 20 per cent. of adult hips, the ligamentum teres vessel is absent, and in all children it is not patent beyond the fovea until the nucleus for the head is well formed at eleven to thirteen years of age, after which free anastomosis occurs.

On the basis of Wolcott's findings, the bone reaction in Case 3, aged five, may be interpreted as follows: The superior capsular vessels were torn with the original injury. The nutrient vessels, already injured, were probably obliterated by introduction of the pin. The ligamentum teres vessel at the age of five had not penetrated the head. The inferior cap-

Fig. 5-A

Case 10. Roentgenogram taken December 7, 1939, shows a typical fracture in a child of eight years, caused by a fall of two stories.

Fig. 5-B

Case 10. Roentgenogram taken December 20, 1939, shows gradual reduction by skeletal fixation of Jones splint on the fractured femur.

Fig. 5-C

Case 10. Roentgenogram taken February 15, 1940, shows firm union. Note: Thirteen months after injury function was good and there was no evidence of aseptic necrosis.

sular vessels, though damaged, were adequate for early union of the fracture but were not sufficient to support the neck and head (Figs. 2-A, 2-B, 2-C, and 2-D).

Case 1. Twelve months after the fracture in a girl, aged nine years, there was extensive necrosis in the neck and marblelike density in the head (Fig. 1-A). It was apparent that the ligamentum teres vessels had not been functioning and that complete disintegration could be anticipated. This is shown in Figure 1-B taken thirteen months later. The neck was revascularized, probably through nutrient arteries (Fig. 1-C).

Case 4. This case of a boy aged eleven may be interpreted with greatest accuracy. The several illustrations, Figures 3-A, 3-B, 3-C, 3-D, and 3-E portray healing reactions with indications of an early loss of the superior capsular vessels. Note the increased density in the upper two thirds of the neck, apparent for several months during the early period of convalescence. The appearance of necrosis in the head may be explained by assuming that at the age of eleven the ligamentum teres vessels had not entered the head and completed its anatomical connections. Had it been present before the accident, the upper quadrant of the head would have survived as did the damaged area of the neck.

Whitman[10], in 1893, called attention to these fractures in children, and during the next few years reported ten cases. Most of these were seen late, and because of coxa vara deformity. He suggested that such cases, if seen early, should be treated by wide abduction and, if separation were present, traction.

Taylor, in 1917, reported seven cases from the Hospital for Ruptured and Crippled. He observed that fractures in older children were similar

to those seen in adults. In the younger children the fractures occurred in the base of the neck, and there was a marked tendency to coxa vara. He advised abduction and plaster when the patient was seen early and had deformity.

Bland-Sutton, in 1918, reported two instances of fracture and called attention to the rarity of this lesion. The next year Greig reported six cases, but did not specify the particular treatment employed. One patient recovered with coxa vara deformity.

Whitman[12], in 1900, again discussed this subject in connection with slipped epiphyses in children. Most of the thirty-one cases were seen late and had considerable deformity. Several others[4, 7, 9] during this early period reported a few cases, usually seen late. They made no mention of changes which would suggest aseptic necrosis.

In 1928 and 1929, Colonna reported twelve cases, eleven of which were cervicotrochanteric in type. Results were good in seven and poor in five. The Whitman abduction plan of treatment was followed in most of the cases.

Mitchell, in 1936, reported nine eases. Only three were treated early, with two good results. The remaining six were seen late in deformity. Mitchell recognized the Hoke-traction plan as the treatment of choice.

John Wilson, in 1940, reported ten cases, emphasizing the difficulties in reduction, and the frequency of aseptic necrosis. He suggested that better methods should be devised for treating this serious injury in children.

Reports in the literature, therefore, should substantiate the conclusion that cervicotrochanteric fractures in children are not satisfactorily reduced and maintained in reduction by the method which has usually been employed in the treatment of fractures in adults.

SUMMARY

Fractures of the hip in children are of infrequent occurrence. The type of fracture is cervicotrochanteric in 75 per cent. of the cases.

Treatment by the methods usually applied in adult cases has not been satisfactory.

After reduction, fixation is best secured by abduction, plaster, and traction. Skeletal fixation in plaster may be substituted for traction.

Adductor tenotomy may be necessary in delayed reduction.

Cases seen late in coxa vara position (after four weeks) should be permitted to unite and then to have the deformity corrected by osteotomy; otherwise aseptic necrosis may supervene.

Aseptic necrosis is a frequent complication. To lessen the damage from it, a long period without weight-bearing should be advised.

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TREATMENT OF TENDONS IN COMPOUND INJURIES OF THE HAND

BY STERLING BUNNELL, M.D., SAN FRANCISCO, CALIFORNIA

TREATMENT OF WOUNDS

Severance of a tendon is an indication to hurry the patient to a hospital where good surgical facilities and surgical skill are available. Without these, suture of a tendon should not be attempted, as it does more harm than good. The fate of a tendon is dependent on the proper treatment of the wound as a whole, because a tendon cannot live long either when exposed or when bathed in infection. Therefore, when tendons are severed, the proper treatment of the wound in general is essential in order to provide an environment of clean primary healing.

In a compound injury of a hand, the outcome is determined by the selection of the primary surgical procedure. Thus, the patient may be spared long illness and extensive crippling by preventing sloughing tendons, infected joints, and osteomyelitis. This can be accomplished by observing the following three main principles: (1) early operation before the germs introduced have become numerous, (2) thorough débridement, and (3) covering over of all vulnerable tissues.

Time Factor

It is preferable to suture tendons within six hours after the accident,—that is, before the bacteria in the soiled wound have greatly multiplied. A tendon should never be sutured after twenty-four hours. Very bad infections frequently result from breaking this rule. In many cases the arbitrary six-hour limit, based on hospital statistics, is unnecessarily short because there are various determining factors other than time alone. If such factors are favorable and a smear from the wound does not show cocci or an excess of pus cells, tendon suturing up to twelve or even twenty-four hours is possible. Judgment in this should be based on the degree of trauma, amount of bacteria, virulence of bacteria, resistance of patient, and the method of wound handling and after-treatment. Infection is less apt to occur in clean cut wounds than in crushing or explosive ones, or those with dirt ground in, and less in wounds incurred indoors with clean tools than those received outdoors. The infections from a human bite or the bite of an animal incurred in a slaughter house are especially prone to be virulent. In a healthy, resistant individual, infection is less likely to occur, mildly contaminated wounds often healing *per primam*. Thus, by considering all factors, including management, primary suture of tendons can be successfully done after six hours, in a gradually decreasing number of cases, up to, but never after, twenty-four hours.

Débridement

Washing a wound with a large amount of normal salt solution does not constitute débridement, as it does not remove from the wound the surface tissues which have been traumatized. Unless careful and thorough excision is done, tendon suturing is frequently followed by severe infection, because the wound must rid itself of a layer of traumatized, infected tissue by necrosis and sloughing.

After the area surrounding the wound has been shaved and cleansed with soap and water, the limb is wrapped in a towel and wound bloodless from fingers to above the elbow with a rubber Esmarch bandage. One and one-half inches above this, where its pressure will not be influenced by removal of the Esmarch, the cuff of a blood-pressure apparatus is applied and pumped to 300 millimeters of mercury, the tubes are clamped and the Esmarch removed. An Esmarch tourniquet may cause paralysis, but a blood-pressure band, so used, will not. After local or block anaesthesia (never adrenalin in the digits), the surrounding area is painted with equal parts of tincture of iodine and alcohol, and the wound is iodized thoroughly.

The wound is débrided—that is, converted into a non-traumatized, aseptic wound—by excising its complete surface while sparing essential structures, such as nerves, blood vessels, and tendons. With sharp, flat, curved, double-pointed scissors, the skin edges are cut away and the whole surface of the wound is systematically excised to a depth of one or two millimeters, or more if the tissue is too badly traumatized. The infected bone ends are chiselled off thinly, the infected ends of tendons and nerves are shaved off, and all the iodine-stained tissue is removed, so that there remains a surgically aseptic, chemical-free wound of viable tissue.

Covering of Vulnerable Tissues

Tendons, nerves, joints, and bones cannot live exposed to the outside world and when infected cause sloughing, months of dressings, and final crippling. Before germs have multiplied all these structures should be covered by plastic skin flaps from the immediate neighborhood. The denuded areas from which the skin flaps are swung should be covered immediately by Thiersch skin grafts.

After the skin flaps are fashioned, the tourniquet is removed, and hemorrhage is checked by steady pressure for a few minutes, and a minimum of No. 000 catgut ties, or even better No. 36 or No. 38 stainless-steel wire which is hairlike and does not interfere with healing.

Postoperative immobility is strictly maintained for at least a week by a half circumference of plaster of Paris. The limb is kept elevated until the tendency to swell is over. Following the operation, mild gauze pressure is applied for a few hours or until the next day to prevent hematoma. The wound is then uncovered and allowed to dry, and is protected only by a wire cage covered by a towel or gauze. Even a dry gauze dressing over a wound becomes moist in twenty-four hours and encourages

infection to enter along the stitches. Dryness prevents this. Antitetanic serum should not be forgotten.

REPAIR OF TENDONS

Indications for Tendon Suture

In disability cases, coming later for reconstruction of solidly congealed and contracted hands, much of the destruction can be ascribed to the very bad infection that resulted from the additional trauma of surgery. Tendons in these hands were often sutured after twenty-four hours following the accident when bacteria were so numerous that they were spread and planted extensively through the hand and wrist by the surgery.

Tendons should never be sutured if the wound is already infected, if over twenty-four hours old, or even within twenty-four hours if in the presence of too much crushed or damaged tissue, or if the wound is too dirtground or badly contaminated; nor should the operation be done with poor hospital facilities or by an unskilled surgeon. It is preferable to leave a severed tendon undisturbed, so that it can be repaired later under good conditions than to do what will make the limb worse.

In recovering tendons for suture, a prevailing fault is to continue an incision upward along the tendon,—namely, to make the "pernicious median longitudinal incision" that cuts across natural creases and pulleys, and leaves a maximal length of adhesions along the tendon resulting in keloids, flexion contracture, loss of gliding surface, bowing forward of tendons, and immobility from adhesions. Instead, a small transverse incision higher up will suffice or a mid-lateral one in the finger. Care should be taken to avoid crossing flexion creases at a right angle or injuring small nerves.

Healing of Tendons

A clear conception of how a cut tendon behaves and heals helps in developing a method of suture. The healing is quite different when a tendon is cut in a sheath than when cut in paratenon formation, and different too when not sutured than when sutured. If cut in a sheath, the proximal end of a tendon retracts further than when cut in paratenon. In either case the distal end retracts only as far as it is drawn when the limb is extended. The tendon ends do not proliferate any more than to become rounded over and sealed by epitenon, and they remain free in the sheath. If infection develops, they become attached to the sheath and cicatricial.

When cut in paratenon and not sewed, each tendon end attempts to reach out to rejoin the other. Extensive proliferation of the paratenon, epitenon, and endotenon, or connective-tissue elements, reaches out like an expanded flame and attaches to anything it can. At first, it is tubular and jellylike, but connective-tissue cells quickly grow in, followed by tendon cells which furnish strength to the attachment. The whole mass then contracts. This blind effort often disables because the flexor

digitorum profundus is held from contracting by this attachment of one tendon, and so can no longer flex the other fingers completely. If instead the pseudopodia of one tendon end meet the other, the tendon mass contracts, cells guided by stress become arranged longitudinally, and the tendon becomes reestablished.

When tendons are sutured, the same rapidly growing fibroblastic proliferation joins the tendon ends as a fusiform splint in four days, and in two weeks is quite advanced, with connective-tissue cells, but without strength. Tendon cells commence to proliferate in four days and bridge the gap in two weeks. They furnish strength, so that in three weeks splints can be removed, and in four weeks the danger of breaking is over. There is much swelling in the first two weeks. After that the connective-tissue elements loosen around the tendon to allow movement. Healing of tendon in paratenon is more active than that within a sheath because of the surrounding paratenon and the greater vascularity. Paratenon and epitenon are to tendons what muscle and periosteum are to bones.

In the above repair process, there is naturally great tendency for the tendon at its juncture to grow fast to the surroundings, and this tendency is stimulated by all factors which provoke tissue reaction, including both infection and surgical trauma. The more elaborate the suture, the greater is the amount of foreign-body material; and the more necrosis which develops from the grasp of the suture, the worse will be the attachment. It is clear that to obtain a free-running tendon, healing should be as reactionless as possible.

The poorest results in tendon repair are of the flexor tendons in the narrow firm tunnel, or sheath, extending from the distal crease of the palm almost to the middle joint of the finger. Here the enclosing firm tunnel does not allow for the necessary swelling of repair, the blood supply is squeezed out, and the tendon within the tunnel undergoes necrosis. Resolution of this results in converting all the tunnel contents into a firm cicatrix. To forestall such a mishap the fascial tunnel should be split its length laterally to decompress, and maintain vascularity of the tendon during the stage of swelling.

It is customary to obtain good results by silk suture of tendons in the forearm where the surrounding tissue, if adherent, moves with the tendon. This is true in the dorsum of the hand where also tendons interdigitate; but in a flexor sheath in a finger, failure is inevitable unless every refinement of method and delicacy of technique is used.

Materials for Suturing Tendons

Of materials for suture, catgut is the least satisfactory. It is coarse and provokes so much reaction, sensitization and otherwise, that its use is followed by infection six times as often (O'Shea[1]) as that of silk. Silk No. 2, untreated, is in general use, but, though superior to catgut, it causes considerable cicatrix about itself. Fine stainless-steel wire, sizes No. 34 and No. 35, provokes the least reaction of all suture materials. It is

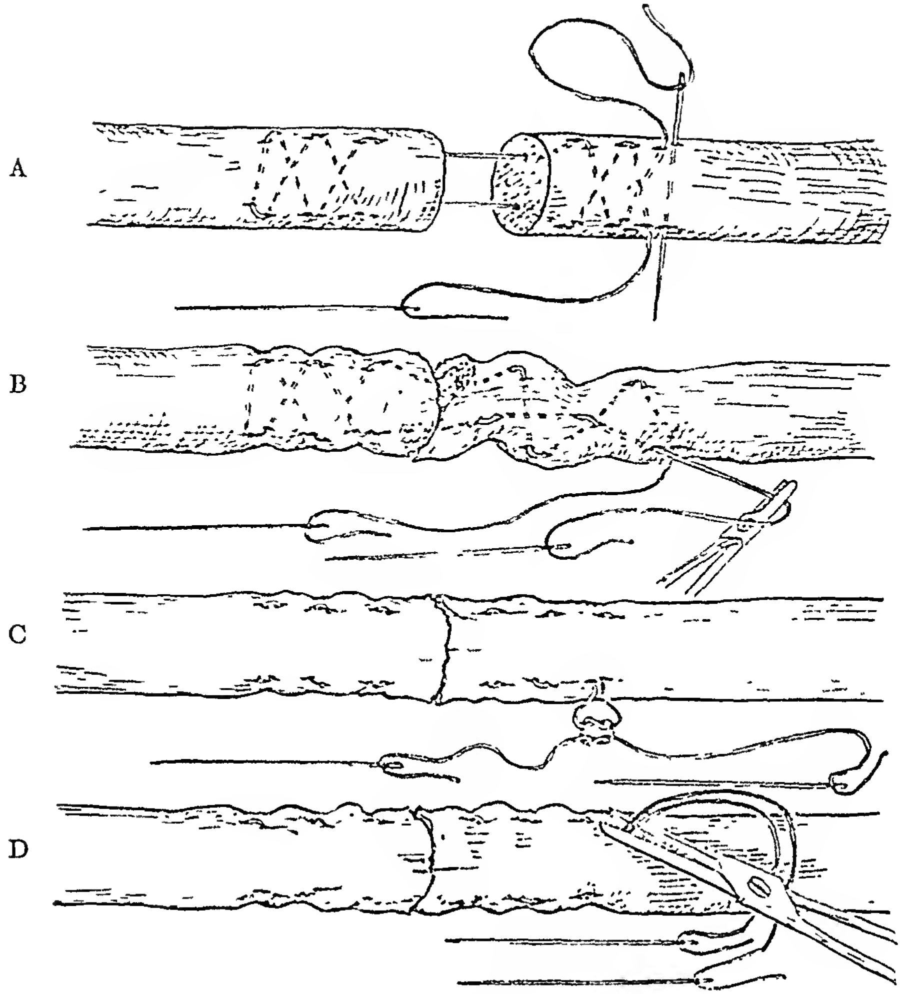

FIG. 1

Stitch for interval repair of tendons with stainless-steel wire. This stitch is too elaborate for primary suture. With No. 34 wire the juncture withstands a pull of five pounds. This stitch when uncovered months later usually shows less reaction in tendons than that from silk. Where it has been subjected to constant angular movement, as at the wrist, it may be found that the wire has broken into many tiny segments which do no harm, or, if not broken, that there are occasionally some signs of mechanical irritation. This is a point in favor of the removable wire suture which we now use routinely.

A. Placing the stitch.

B. All slack is removed by pulling on one wire at a time. The tendon slips on smooth wire and allows itself to be bunched up on the wires. This prevents separation of the tendon ends later.

C. A single knot, which sinks into the tendon when tied, is used remote from the suture line.

D. The ends of the wire are cut off, after being again passed through the tendon, so they will be left embedded within the tendon.

non-electrolytic and is apparently inert on the tissue in which it lies. It slides well through tissue and is, for its strength, finer than silk,—a suture with No. 34 will withstand a strain of five pounds. Great care should be used to avoid kinking the wire as this will cause it to break. For five years the author followed Babcock in using it for wound closure and for three years has used it for tendon suture. Tendons containing this

suture which were uncovered later, usually showed an even more normal appearance than those containing silk. In some cases where there had been continual movement over many months, the wire had fragmented into short segments, but these were not doing harm. Occasionally signs of mechanical irritation from the wire, due to movement, were found. A method has been developed of so placing the stitch in the tendon that it is removable in three weeks when the tendon will have physiologically united, thus leaving the tendon junction free from any suture.

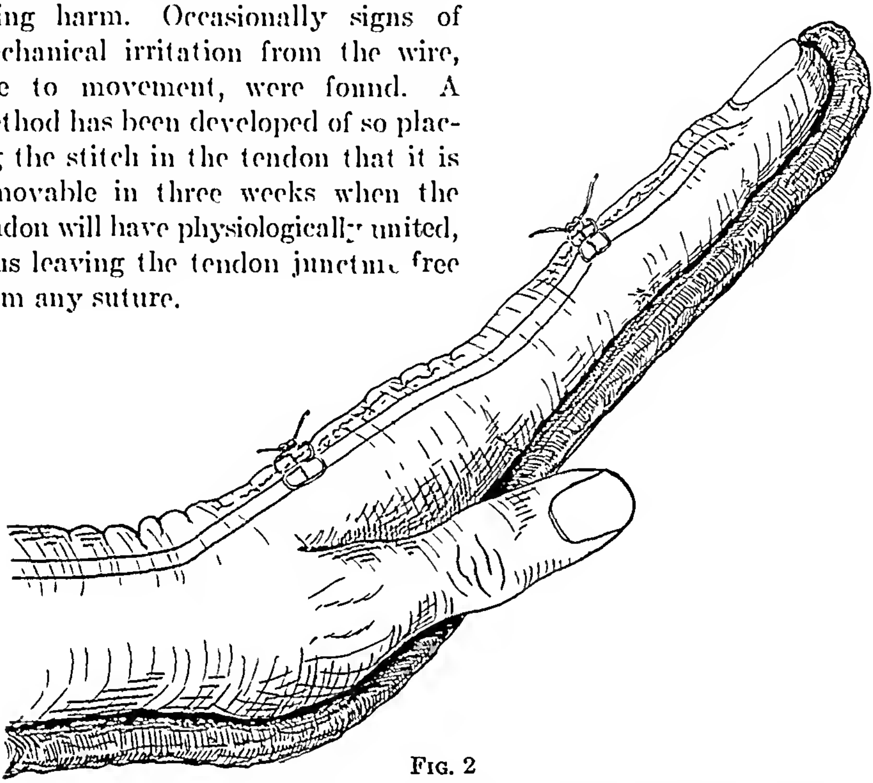

Fig. 2

For primary repair of extensor tendons a simple figure-of-eight stitch with No. 35 stainless-steel wire is used. One loop unites the tendon ends and the other the skin edges. The stitch is without strength and is merely for approximation of tendon ends. Splinting, as shown, prevents the tendon ends from pulling apart.

Type of Stitch

In the primary repair of tendons the stitch should be the simplest possible. In order to hold, it must cross some fibers for a spliced effect but this should be minimal. A single stitch placed longitudinally will split through on slight tension. A core suture (Fig. 1) is less likely to cause adhesions than one in which the suture is on the surface of the tendon. The smooth glistening epitenon surrounding the tendon should not be even scratched. The suture material should be fine and largely sunk out of sight into the tendon. All slack should first be withdrawn by pulling the sutures taut. Otherwise the tendon ends will pull apart somewhat during healing. There will be some central necrosis from this tightness, but it will eventually be replaced by tendon cells.

To prevent tendon ends from pulling apart more reliance should be placed on splinting, with joints flexed to relax the tendons, than on the strength of the suture (Fig. 2). In three weeks fairly strong physiological

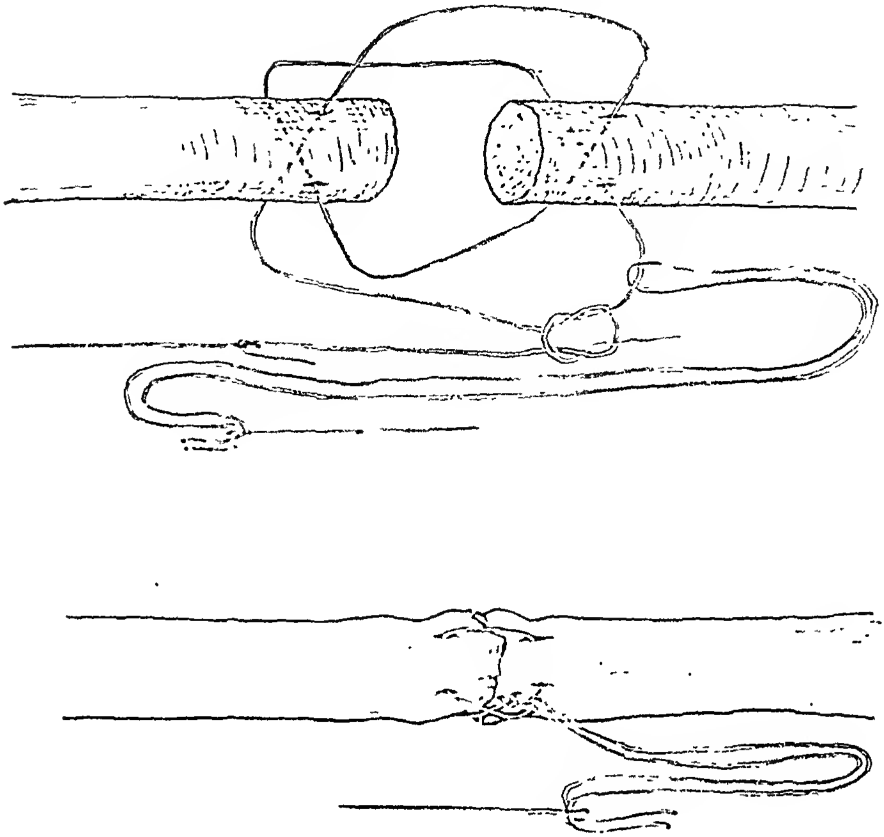

Fig. 3

Double right-angle stitch. This stitch is more than twice as strong as two simple through-and-through stitches because in each tendon end the stitch crosses diagonally a quadrant of tendon fibers. This displaces till somewhat on the bias as the stitch is pulled, all strands thus making for added strength. The four strands give a basket effect for better approximation of the tendon ends and divide the strain, so that as small as No. 35 wire can be used. The stitch is simple and quickly placed. To prevent breaking more reliance is placed on splinting the wrist in flexion to relax the flexor muscles than on the strength of this stitch. A pull-out wire is placed under the knot as shown, drawn out through the skin and left in place. If infection develops later, the stitch can be withdrawn as soon as the tendon unites, or if healing is *per primam*, the pull-out wire may be withdrawn.

union allows removal of the splint. Half circumference plaster of Paris is best for this. For flexor tendons it is molded on the dorsum of the hand and forearm with the wrist flexed, but with the digits free for some feeble action. For extensors the splint is placed on the volar aspect and holds the wrist and digits in dorsiflexion. The latter keeps extensor tendons so well relaxed that the only suture necessary is a simple figure-of-eight through the skin with one loop and through the tendon ends beneath with the other; this is kept *in situ* for three weeks. These extensor tendons so interdigitate that splinting alone often suffices, though the accuracy of union gained by one stitch is advisable if we gauge our results critically.

For flexor tendons in palm or forearm a useful quick stitch that holds fairly firmly is the "right-angle double" (Fig. 3). The needle is thrust straight through the tendon four millimeters from the end, repeating in

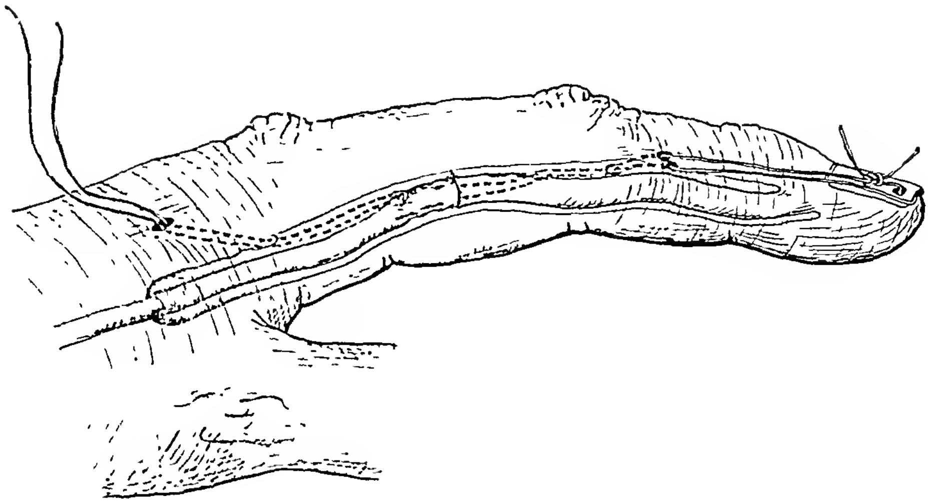

FIG. 4

Withdrawable stitch of stainless-steel wire. The stitch is made fast into the tendon end which is attached to the muscle and then anchored to the outside of the limb, in this case through the fingernail. A tiny stitch of blood-vessel silk or No. 40 stainless-steel wire approximates the tendon ends. The distal tendon end is passive and does not exert a pull. A pull-out wire is seen looped through the proximal loop of the stitch and brought out through the skin. Both the pull-out and the stitch wires are made to traverse the tendon sheath some distance before emerging through the skin. This allows some to-and-fro movement of the tendon in the sheath without causing parting of the tendon ends.

In three weeks, when the tendon is physiologically united, the stitch is withdrawn. After cutting off the stitch wires at the skin, the stitch is drawn out backwards by its loop by the pull-out wire.

the other tendon end as in the simple longitudinal stitch which will not hold. Another similar stitch is placed at a right angle to the first. The ends of the stainless-steel wire are then tied fairly tightly. No. 35 instead of No. 34 wire can be used, as four instead of two wires divide the strain. The four wires also hold the tendon ends cagelike and in better approximation. The strength of this suture is due to crossing the tendon fibers in two quadrants, but when used the tendon should be left in constant relaxation by keeping the wrist flexed by a plaster-of-Paris dorsal splint, as the juncture is not strong. These sutures can be placed so they may withdrawn or not at will.

Withdrawable Tendon Sutures

Convinced that complete absence of suture, when after three weeks the tendon has united, is most favorable for a free-running tendon, a method has been developed by which the suture can be withdrawn (Fig. 4). After a tendon is sutured, only the end of the tendon attached to the muscle exerts a pull. Therefore, the suture is spliced securely in this end and the two ends are passed some distance down through the center of the distal tendon and on out through the skin. By pulling upon these sutures from the outside and anchoring them securely, the proximal end can be drawn down until the tendon ends are held approxi-

FIG. 5-A

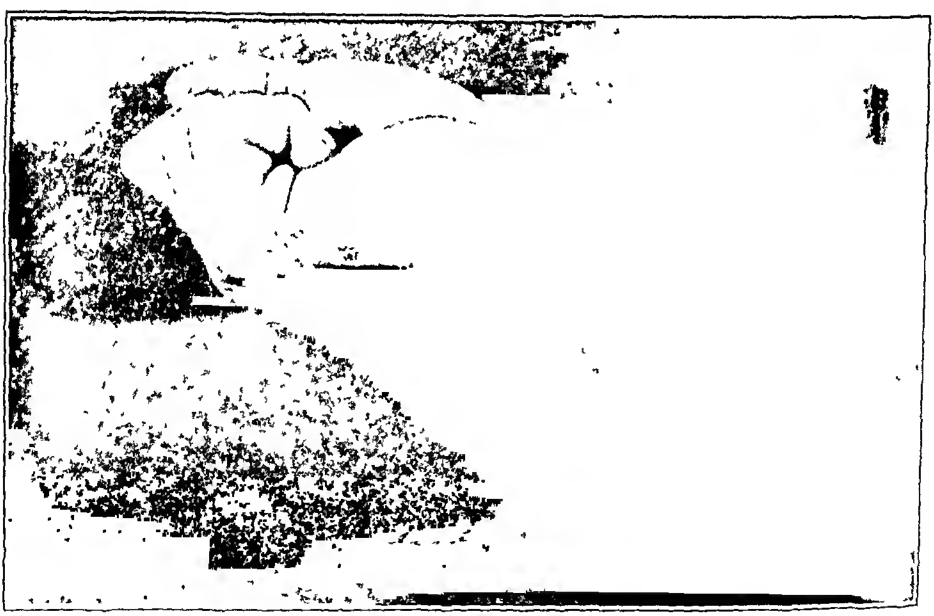

FIG. 5-B

G. H. Result in case of primary repair of severed flexor tendons in little finger sutured in the proximal segment, a part of the finger notorious for poor results. Removable stainless-steel wire No. 34 was used by the method shown in Fig. 4.

mated. Only one tiny stitch of blood-vessel silk or hairlike wire is then necessary for exact approximation of the tendon ends.

For the later withdrawal of the stitch a pull-out wire is left in place which will draw the stitch out backwards by its loop whenever the two stitch wires are cut. Both ends of the pull-out wire, after being placed through the loop of the stitch in the proximal tendon end, are threaded on a needle and passed up through the sheath some distance and out

FIG. 6-A

FIG. 6-B

E. M. Another case of primary repair of severed flexor tendons.

through the skin. The play of the wires through the sheath will allow a little movement in the tendon without strain on the juncture.

Tension is relieved by flexing the joints. The stitch wires can be anchored to the outside of the limb by passing them through adhesive plaster applied to the skin and then fastening them through a button, by "split shot" or to a loop of adhesive plaster over the end of the finger, or by tying the wire ends through a perforation in the fingernail. If any resistance is encountered when withdrawing the stitch by the pull-out wire, tension may be applied by fastening a light rubber band to the wire. At the next dressing the stitch will be out. The bend of the pull-out wire, where it loops through the stitch, should be pinched sharp, so that it will not encircle tissue.

If the right-angle double stitch is used, it can be made optionally withdrawable by merely laying a pull-out wire across under the knot as it is being tied. The two ends of the pull-out wire are then threaded on a

needle and brought out through the skin. If infection occurs, the stitch can be withdrawn, but if it does not, the pull-out wire alone is withdrawn after cutting off one of its ends just inside the skin.

General Considerations

Block anaesthesia is generally used with the ischaemia of a tourniquet. An injection is made of five cubic centimeters of 2-per-cent. novocain plus adrenalin in the ulnar nerve at the elbow, the median nerve above the wrist, and the branches of the radial nerve as they reach the superficial fascia. If the case is extensive, general anaesthesia is preferred.

It is important for the surgeon to be comfortably seated and to work across an arm board with an assistant. The arm board is made steady on a firm base and the patient's hand is held immobile by the assistant who presents it properly to the operator's line of vision under a bright but not a hot light.

If in a finger the flexor sublimis tendon is cut, it need not be sutured, but if both flexors are cut only the profundus should be repaired, and the sublimis should be removed. If both tendons are sutured, they will adhere to each other and thus act on the middle joint alone, but not on the distal joint. The profundus tendon sutured in the middle segment of the finger may yield a fair result, as it need pull through but one joint and not two as in the proximal segment. Also, if it adheres it may later be freed with some advantage. Flexor profundus tendons are essential for good function, but sublimis tendons are not so important. They help the muscle balance of the fingers and furnish the final tight clenching. Good results are obtained in ruptured insertions of extensor tendons if the finger is splinted early in hyperextension of the distal and flexion of the middle joints. Suturing is unnecessary in fresh cases.

Flexor severance in the proximal segment of a finger is not only the most common tendon injury, but is followed by the poorest results. When the problem of repairing a flexor tendon at this site is solved, the repair of all tendons will be comparatively easy.

CONCLUSIONS

Primary repair of tendons in open wounds is dependent upon obtaining primary healing in the wounds in general.

Essentials are prompt operation, thorough débridement, covering over all vulnerable tissues, and adequate after-treatment, consisting of splinting, elevation, and dryness.

The technique of tendon suturing is based on physiological healing.

Stainless-steel wire is superior as a suture material.

Irritation from suture is terminated by withdrawing the suture from the tendon in three weeks.

The fascial tunnel or sheath in the proximal segment of a finger should be split laterally when repairing a tendon within it.

1. O'Shea, M. C.: Severed Tendons and Nerves of the Hand and Forearm. Ann. Surg., CV, 228, 1937.

SUBFASCIAL HEMATOMA AS A COMPLICATION OF CRUSHING INJURIES TO THE FOOT

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Due to the form of the human foot and its manner of functioning, the forefoot is constantly exposed to crushing injury. Heavy objects may fall upon the unprotected feet of laborers, while the feet of pedestrians may be run over by vehicles or caught in sliding doors or escalators. Marked subfascial hemorrhage on the dorsum of the foot usually accompanies such injuries. Local circulatory obstruction of varying degree is produced immediately. Unless this subfascial tension is promptly relieved, permanent damage is done to the soft structures of the forefoot.

This report is based upon four such cases. Three were acute and were given immediate attention, whereas one patient was admitted twenty-four hours after injury. This last-named patient developed a relatively large trophic ulcer on the dorsal surface of the forefoot. Because of the delay in admission, the area had become devitalized by pressure of the underlying hematoma.

From a study of the anatomy it is evident that crushing injury to the foot may produce serious complications, because of the vulnerability of the blood vessels. The horizontal and perforating arteries, for the most part, lie beneath the dorsal fascia. The deep veins communicate with the saphenous system by means of perforating branches through this fascia. Passing transversely across the anterior aspect of the ankle are two well-defined bands of tissue, the cruciate and transverse ligaments (Fig. 1). The strips are continuous below with the dorsal fascia.

Following trauma, these ligaments, particularly the cruciate, may become constricting bands to produce circulatory obstruction. Immediately after the injury there is local vasodilatation and a bulging out of the fascia due to the confined subfascial hemorrhage. Because the dorsal fascia blends laterally with the thick plantar fascia, this hemorrhage does not pass readily into the sole of the foot. The venous flow from the toes is obstructed first, and, as noted in Case 1, the condition is rapidly progressive. Another factor is that most persons so injured are brought to the hospital with the fractured foot dependent. If a traumatized foot is elevated promptly after injury, a complete circulatory block may be prevented. In violent crushing injury, however, the arterial hemorrhage rapidly fills the subfascial space and the distal forefoot quickly becomes cold and cyanotic (Fig. 2). Marked oedema, which obscures the true condition, later appears in the loose subcutaneous tissue.

To determine, experimentally, the rôles of the cruciate and transverse

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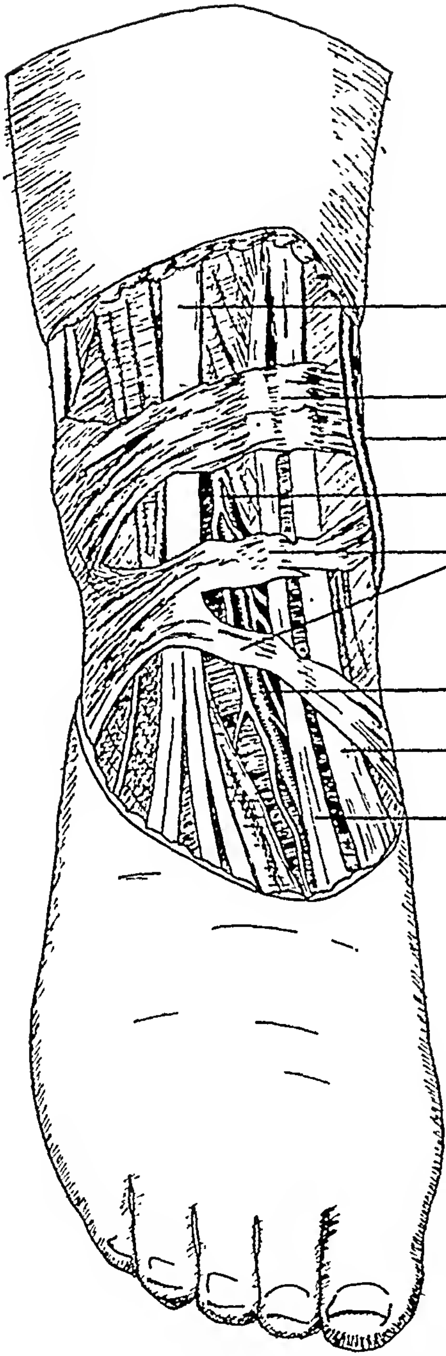

Fig. 1

Cruciate and transverse ligaments. (Drawn by Merrill Leinbach from Cunningham's Manual of Practical Anatomy, Ed. 7, Vol. I, p. 349. Edinburgh, Glasgow, and London, Henry Frowde and Hodder & Stoughton, 1919.)

ligaments in subfascial hemorrhage, six feet from unembalmed cadavera were injected with a solution of black dye and physiologically normal saline. The evidence obtained was more indicative than conclusive. Injections varying in amount from 50 to 200 cubic centimeters were made beneath the deep fascia on the dorsum of the foot and into the dorsal

interosseous spaces. Dissection was done from five to thirty minutes later with exposure of the fascia, tendon sheaths, and the cruciate and transverse ligaments. Particular attention was given to the cruciate ligament, and the belief that this ligament would act as a confining band in deep fascial injections was confirmed in every instance. In ten to fifteen minutes, however, a small amount of the dye solution passed beneath the ligament to continue upward to the transverse ligament where it was delayed still further. In two of the feet injections of 150 and 200 cubic centimeters were made after the fascia and the ligaments had been exposed. The dorsal fascia ballooned out considerably up to the cruciate ligament which was put under tension. When this ligament was sectioned transversely in the mid-portion, its ends separated 3.5 centimeters in one foot and 4.6 centimeters in the other. It was suggested that a dyed acacia solution be used rather than the saline. This method was employed in two additional feet with identical results. In no case did the fluid pass beyond the edge of the sole and none extended beyond the webs of the toes.

Conclusions from these injections into unliving tissue are made with reservations since the actual changes occurring in living traumatized feet cannot be produced.

Treatment depends largely on the severity of the case. The general condition of the foot should be considered first rather than the fracture. If deformity due to the latter is causing additional venous congestion, reduction should be done and retained by skeletal traction or pillow splint. If the patient is seen soon after the injury and only a moderate venous obstruction is present, elevation of the foot, application

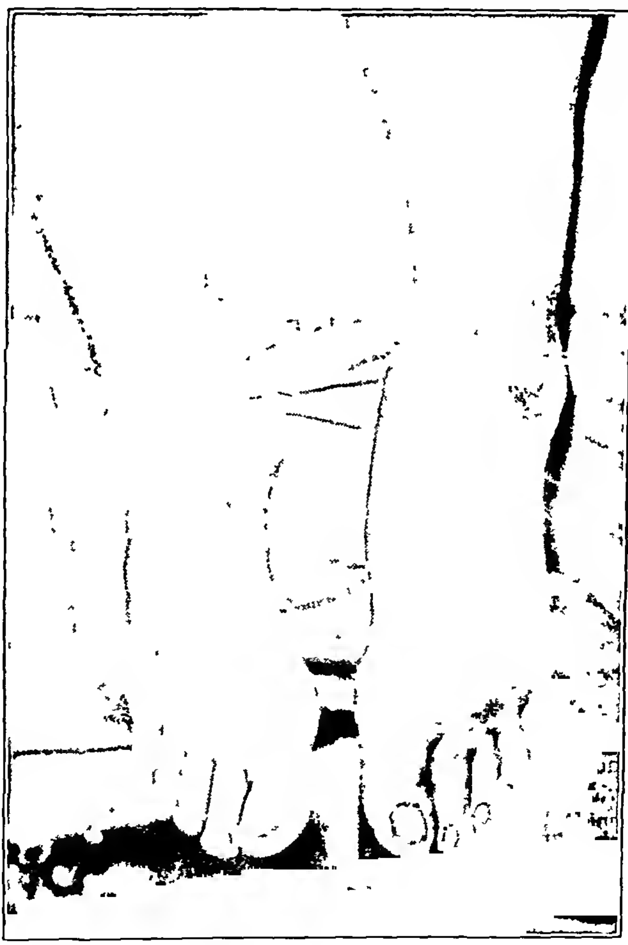

FIG. 2

Case 3. Crushed foot showing swelling and cyanosis.

of ice packs, and gentle centripetal massage of the foot and ankle should be tried. In many of these cases such treatment is adequate. In severe cases the hematoma should be released at once by multiple incisions through the fascia. Soft rubber drains should be inserted and the wound left open. If this is not effective, then sectioning of the cruciate and transverse ligaments must be considered. Aspiration of the hematoma with a large-bore needle usually gives only temporary relief (See Cases 2 and 3).

Metatarsal fractures are usually found following such trauma, but soft-tissue damage alone may produce an identical clinical picture. The entire forefoot becomes swollen and firm. The skin over the dorsum is stretched tight and is cyanotic. The toes are cold and insensitive to pain and temperature changes; the dorsalis pedis is not palpable. This injury, to some degree, is comparable to the subfascial hemorrhage in the forearm preceding Volkmann's contracture. The resultant muscle damage on the dorsum of the foot is negligible, however, as only the extensor digitorum brevis and dorsal interossei are exposed. As far as could be determined, these muscles were not affected in any of the four cases.

CASE REPORTS

Case 1. White female, aged seventy-two years, had her left foot run over by an automobile twenty minutes before admission to the hospital. There was a tense fluctuant swelling over the dorsum of the foot; pulsation of the dorsalis pedis was absent. There was a definitely depressed line about four centimeters in width across the dorsum of the foot at about the level of the cruciate ligament. The toes were cold, bluish-black, and did not react to sensory stimuli. Roentgenograms showed a fracture of the fifth metatarsal bone without displacement. For one and one-half hours the patient refused treatment while the area of cyanosis and anaesthesia spread up from the webs of the toes to the mid-tarsal joint. All the swelling remained confined to the anterior and anterolateral portions of the foot. The plantar area was relatively normal in appearance.

Two two-inch longitudinal incisions were then made down through the deep fascia proximal to the first and third metatarsal heads. Several large soft blood clots were removed and about sixty cubic centimeters of dark blood was evacuated. Soft rubber drains were inserted, the wounds were left open, and the foot was elevated beneath a light cradle. Immediate improvement was noted, and twelve hours later the foot remained only moderately swollen and discolored. Six days later the color and sensitivity of the foot were practically normal. Pulsations of the dorsalis pedis artery, however, did not return.

Case 2. White boy, aged thirteen, was struck by an automobile which ran over his left foot. He was brought to the hospital at once with a compound posterolateral dislocation of the ankle and with the entire forefoot cold, cyanotic, and insensitive. The dorsalis pedis artery was not perceptible. He was in moderate shock. As the dislocation appeared to be causing a circulatory block, the wound was scrubbed with green soap and the dislocation was reduced. As the circulation did not return, and as there was evidence of a subfascial hematoma, about thirty cubic centimeters of dark blood was aspirated. The circulation and sensitivity returned almost immediately to the toes and to the dorsal forefoot. Roentgenograms showed a transverse fracture of the mid left tibia and fractures of the second, third, fourth, and fifth left metatarsals. Two hours later the toes and forefoot were again cold, cyanotic, and anaesthetic. Two longitudinal incisions were made through the dorsal fascia and about fifty cubic centimeters of dark blood with a few soft clots was removed. Drains were inserted and the wounds were not closed. The leg was elevated beneath a light cradle and the drains were removed twenty-fours hours later. The foot appeared normal the next day and circulation to it remained unimpaired throughout convalescence.

Case 3. White male, aged thirty-two, was injured while unloading lumber from a truck. Several large timbers fell upon his left leg and foot. On admission shortly afterward the dorsal fascia of the foot was tense because of deep hemorrhage and the ankle joint bulged with fluid. He complained of numbness over the entire foot. Roentgenograms of the foot showed fractures, with only slight displacement, of the first cuneiform, third and fifth metatarsals, and the calcaneum. Eighty cubic centimeters of blood was aspirated from the dorsal subfascial space and the ankle joint. The circulation improved to such an extent that a plaster casing was applied and the extremity elevated. The patient soon complained of severe pain, and upon bivalving the plaster the foot was found to be discolored and cold. Multiple releasing incisions were considered but not done. The leg was elevated higher and a heat cradle placed over it. The circulation showed some improvement, but in twelve hours multiple large fracture blisters appeared over the foot and ankle. Despite later intensive physical therapy a marked brawny swelling persisted for a period of over three months.

It is believed that multiple deep-fascial incisions should have been made in this case. According to Mock [1] such a failure to relieve immediately the subfascial swelling results eventually in a painful foot accompanied by cyanosis, clammy skin, and thickened swollen tissues. The convalescent period is extended to an extreme degree and the end result is apt to be disappointing. He calls such a result the "congealed" foot.

Case 4. Colored boy, aged six, was admitted to the hospital twenty-four hours after his left foot was run over by an automobile. The circulation to the third toe was completely obstructed and he had moderately severe swelling of the forefoot. The toe could be moved actively, but was insensitive to stimuli. Twelve hours after admission a hematoma was removed from beneath the fascia by longitudinal incision. The skin and subcutaneous tissue, as seen at the operation, appeared grayish in color, and devitalized. Both the circulation and sensitivity returned to the third toe within twelve hours. Two days later, however, an area the size of a silver half dollar sloughed out. The ulcer required a period of several weeks to fill in with granulation tissue.

SUMMARY AND CONCLUSIONS

1. Subfascial hemorrhage of the dorsum of the foot frequently complicates metatarsal fractures and soft-tissue damage caused by crushing trauma.
2. The cruciate ligament of the foot may act as a constricting band in subfascial swelling. This condition was produced in eight feet of cadavera injected with dye solutions.
3. Immediate multiple incisions to release and to remove the subfascial hematoma is the treatment indicated in severe cases.
4. Release by transverse section of the cruciate and transverse ligaments of the foot and ankle should be considered in persistent circulatory block.
5. Delayed or inadequate treatment results in the "congealed" foot or in necrosis of the soft tissues of the dorsal forefoot and toes.

Acknowledgment is made for the helpful suggestions of Kenneth C. Farnsworth, M.D., of the Department of Anatomy, Harvard Medical School, in the making of this study.

1. Mock, H. E.; Pemberton, Ralph; and Coulter, J. S.: Principles and Practice of Physical Therapy. Vol. II, pp. 111 and 119. Hagerstown, Maryland, W. F. Prior Co., Inc., 1934.

SLIPPING OF THE UPPER FEMORAL EPIPHYSIS

End Results After Conservative Treatment

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It is the desire of the author to report in this paper the results of treatment for slipping of the upper femoral epiphysis by a conservative method. The study is based on her experience with twenty-two cases treated at the Bath and Wessex Orthopaedic Hospital and followed for a number of years. No claim is made that this treatment by manipulation produces anatomical reduction or perfect function; however, it has given sufficiently good functional results to warrant reporting, particularly in view of the fact that operative methods of treatment do not bring about 100-per-cent. "cures", while some involve a certain risk to life and others may damage the articular cartilage. Moreover, it is not possible to have all cases cared for in the larger centers where more complete equipment is available.

It is impossible to assess the value or the results of a method without analyzing some of the features of the cases treated and the nature of the disease. Accordingly, a brief review is presented of the findings in the series of cases under consideration.

Displacement in adolescents has many features in common with fracture of the neck of the femur in the aged, but differs in that there is usually no actual separation of the fragments, but only a bending and twisting of the cartilage, and particularly a turning of the head backward on the neck, which often makes reposition difficult. When anatomical reposition is shown roentgenographically, the problem of fixation is not only one of maintaining exact contact for a matter of weeks, until new bone bridges the gap, but also of reducing stress on the cartilage of the weak neck until growth and metabolic changes have strengthened it sufficiently for weight-bearing and the rough usage of a normal adolescent's life.

It should be emphasized that the object of treatment should be to obtain a joint whose range of movement, however limited, is through the most valuable or important arcs, rather than perfect reduction as shown by the x-ray, with a flexed, abducted, or adducted limb. It has been the experience of the writer that, with the technique to be described, there has been a tendency toward a slight increase in the range of motion as the years have passed; whereas cases have been reported where good motion was obtained by more radical measures, but stiffness has gradually developed and good position has not been maintained.

FACTORS WHICH INFLUENCE THE RESULTS OF TREATMENT

Metabolic Disturbances

Endocrine abnormality was evident in nineteen of the author's twenty-two cases, with the usual physical signs of excessive weight and

height. Some showed increased sugar tolerance, and most of these improved when treated by thyroid, but in some, benefit was obtained only after thyroid had been given alternately with fortnightly courses of injections of pituitary whole gland. This treatment was supplemented by measures to improve the calcium metabolism and to reduce the weight imposed on the weaker structures. All of the patients were treated in the open air, with heliotherapy, and a diet rich in vitamins.

Of three thin patients, one had recovered from a tuberculous knee, one had a rheumatic heart, and the other had spasmodic flat-foot.

Latent Sepsis

There were three patients with fibrositis and joint stiffness in other parts of the body, three with septic tonsils which required removal, and one with goiter of the adolescent type. Possibly these factors are only in a proportion normal to the child population.

The factor of sepsis is important, because, if the patient should develop a tendency to joint stiffness, this might be aggravated by forced manipulation of the joint or by operation in and around the joint.

Vulnerability of Growing Tissues to Strain in Adolescence

The influence of growth is one of marked importance. In adolescents, if weight-bearing can be brought into a good mechanical condition, the bone will then reconstruct itself and tend to restore its femoral neck and shaft. This tendency is shown very distinctly and prominently after Lorenz's bifurcation osteotomy for congenital dislocation of the hip, and the same restorative forces are at work in the healing of any disease of the femoral neck and head, provided unfavorable strain can be abolished.

There is no quick cure for a slipped epiphysis. With the head once in favorable position for healing, the position must be maintained for a long time, which may not be the same in any two cases. In the author's opinion, it is not until bony trabeculae can be seen unmistakably to cross the epiphyseal line from the neck to the head, that safety against relapse is assured. Union of the upper epiphysis on the injured side tends to occur before it does on the sound side, although it must not be forgotten that cases often are bilateral.

Although this is in a sense a growth disease, it does not lead to any appreciable shortening. One-half inch was the average in the author's cases. There was shortening of over an inch in only one patient, and that was a boy with a rheumatic heart who grew rapidly while the leg was kept in fixation.

Age at Onset

Sixteen of the twenty-two cases occurred between the ages of twelve and fifteen years. The youngest patients were two overgrown girls of ten years; two were eleven; and two extremely tall boys were sixteen and seventeen respectively. It might be thought that the younger cases

would show the best results; whereas, of the four hips which ultimately became stiff, two were those of girls of ten and eleven years, treated by different methods, and two were of girls of fourteen.

Interval Between Onset of Symptoms and Treatment

The length of time between the onset of symptoms and manipulation might be thought to have a great influence on the result, but this is not borne out by the results in the cases under consideration.

It is extremely difficult to know what date to consider as the beginning of the disease, because in practically every case there had been months of vague pain in the groin or down the thigh of the affected side, often with intermittent limping, before the patient was brought to the doctor. In most cases there was the usual history of some sudden but rather trivial injury. This suggests that the softening process in the bone gives rise to vague discomfort before it weakens the tissues enough for slight trauma to cause displacement.

Bone-Softening

The existence of generalized and persistent bone-softening in these cases is demonstrated by the frequency of severe knock-knee as a complication, much aggravated if there is spasm of the hip adductors. Ten patients, both girls and boys, showed this complication, and it varied in severity from a gap of one and one-half inches to four and one-half inches between the malleoli, when the patient was seated. When plaster is being applied to the hip, great care should be taken to see that the assistant who holds the limbs corrects this deformity as much as possible; if one is not careful, his zeal to keep the hip abducted results in his pulling the tibia outward on the femur! The presence of knock-knee is one of the factors that make treatment without abduction of the hip desirable.

TECHNIQUE

In the earlier cases it was considered that a preliminary loosening of the fragments was necessary, and in seven cases Kirschner wire was applied, with traction on the femur by weights of from fifteen to twenty pounds, for three weeks. In four of these cases, the wire was removed under general anaesthesia and the hip manipulated and placed in plaster. The other three were treated by splinting, as the external rotation and flexion of the hip had become corrected under the traction. The x-ray results of these cases were disappointing, as the only effect of the heavy weights had been to pull the hip below its normal level in the acetabulum without affecting the relation of the head to the neck. In view of the experience with these earlier cases, skeletal traction was discarded, although there may be exceptional cases which would benefit by it. In the last eleven cases of the series the writer has used the following simple technique.

An anaesthetic is given in almost all cases. With the method of Leadbetter always kept in mind, an attempt is made to bring the hip into

Fig. 1-A

M. S. Female, aged fifteen years.

Roentgenogram taken June 3, 1935, one month after onset of pain and limp. Thirteen months before, she had fallen on polished floor.

After treatment by piano-wire traction for three weeks, the hip was placed in plaster for three months, in internal rotation with no abduction. Girl kept in bed for two weeks, until muscles were good; then allowed up but used walking caliper for three months.

Fig. 1-B

M. S. Roentgenogram taken October 12, 1937, two years after treatment.

Patient seen early in 1940. She is now twenty and has been working as a dressmaker and mannequin. Her present range of motion shows 70 degrees of flexion in each hip, full extension, little rotation from neutral, adduction equal on both sides, but abduction not quite equal on both sides.

full internal rotation (an amount at least equal to the maximum obtained on the sound side), but this can seldom be accomplished except by first flexing and then adducting the hip. After this it is usually possible to internally rotate the limb into extension without losing the internal rotation, and gentle, steady pressure may be necessary to prevent its springing back into external rotation. This position must be held until the limb lies naturally in internal rotation. A plaster spica is then applied with the limb in this position, maintaining definite extension with a minimum of abduction. The foot is included in the plaster. When the plaster has dried, the patient is allowed to walk and to return home for three months, at which time he is readmitted for x-rays and observation. If sufficient abduction is present, a lateral roentgenogram taken with the limb in "frog" position is valuable to show the relation of the head to the neck, with the sound side for comparison. Until the epiphyseal line is crossed by trabeculae, it is deemed that slipping may recur, and a series of plasters are reapplied until this is obtained.

RESULTS

Eleven patients, six girls and five boys, have been treated in the manner described, at periods of from one to three months after onset of symptoms in six cases and from six to twelve months in five cases.

Serial x-rays of these cases every few months for years after the manipulation show interesting and progressive reconstruction of the upper end of the femur, by which the line of weight-bearing is gradually deflected into normal lines with increased density of new trabeculae, which crystallize in the lines of stress and absorption of parts. This crystallization is not so evident in the parts which no longer function, like the lowest quadrant of the head. The upper border of the neck resumes its normal line, concave downward. The neck does not usually become as long as that on the sound side, nor is the head quite normal in shape, and it is possible that investigation of these cases twenty or thirty years hence will show an undue proportion of osteo-arthritics. That may be an inevitable sequel of the disease, as of so many abnormalities of the hip.

In all cases full extension of the hip and internal rotation to neutral were maintained; in only one was internal rotation increased even though all had been fixed in plaster well beyond neutral. All patients walked with a normal attitude; all had some limitation of flexion, but were able to sit without discomfort. Nine had limitation of abduction and adduction, and of external rotation; only one had a full range of motion in all directions.

As regards working capacity, seven (three girls and four boys) had been at full work in the open labor market for several years when recently seen,—some as engineers, some in shops, in factories, and in domestic work, and one in a timber yard. Two were attending ordinary schools; two had moved to other areas while still of school age, and attendance is unknown; two females were only helping at home.

FIG. 2-A

D. N. Male, aged fourteen years.

Roentgenogram taken on admission, July 31, 1934, four months after onset of limp and pain in hip.

After manipulation into internal rotation under anaesthesia, the hip was put into plaster spica (in which the foot was included) for three weeks. The patient was kept prone and treated by massage. He used a walking caliper for several months.

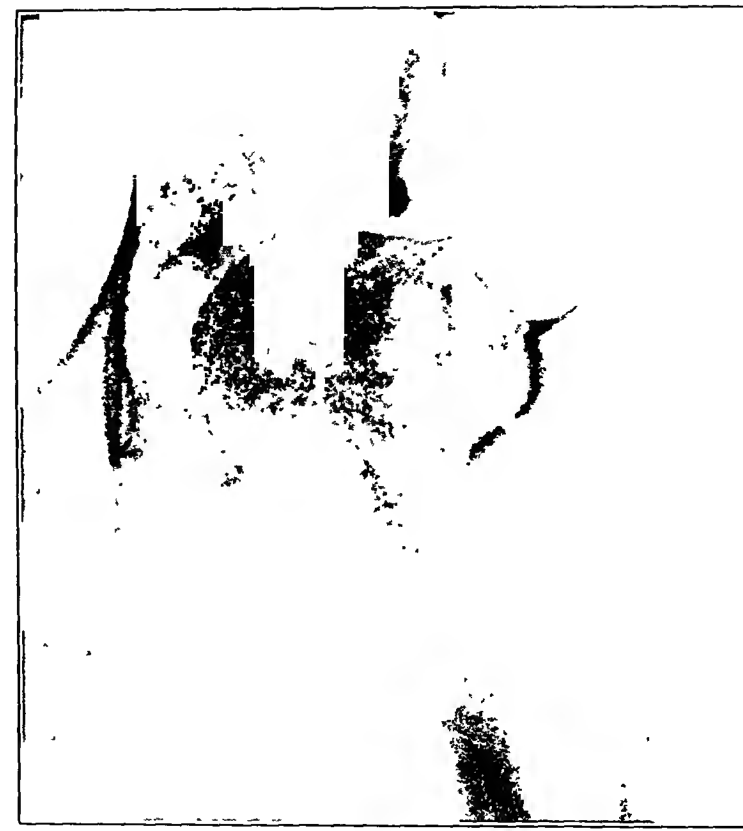

FIG. 2-B

D. N. Roentgenogram taken June 27, 1939, five years after manipulation.

He has been working as an electrical engineer for several years and was recently accepted for the army. He has full range of motion in the hip except that there is no internal rotation beyond neutral.

One boy of twelve years was admitted to the Hospital with the characteristic deformity and endocrine defects, but the x-ray showed no displacement, only an irregular epiphyseal line, and his symptoms cleared up with recumbency and massage, without splinting. When he was allowed to go home in one month, he had full range of movement which was still maintained when seen eighteen months later. This is the ideal result and suggests that in this disease, as in so many others, the essence of good treatment is early diagnosis, and that "sprains of the hip", like those of other joints, should be x-rayed at once and treated as if serious.

Unless such early diagnosis is possible, the writer contends that in properly selected cases the simple manipulation and persistent plaster treatment outlined will produce hip joints with good function, and that the results compare favorably with those of methods more difficult to carry out and more dangerous to life and limb.

MUSCLE TESTING AROUND THE SHOULDER GIRDLE

A Study of the Function of Shoulder-Blade Fixators in Seventeen Cases of Shoulder Paralysis

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Because of the great number of muscles which directly or indirectly participate in the movements of the shoulder girdle and the arm, it is very difficult to determine the specific function of each muscle. When studying origin and insertion of muscles on a skeleton, or when dissecting muscles on a cadaver, the exact anatomical position can be learned, and conclusions may be drawn as to their probable function. However, it has been shown repeatedly that, although a muscle may have a perfectly good anatomical position for carrying out a movement, it often lies inactive when that movement is performed. The function of muscles, therefore, must be studied primarily on the living human body. Careful observation and palpation of muscles on the normal individual yield a great deal of information; but for a thorough understanding of muscle action additional studies of paralysis cases are imperative. If the paralysis involves a number of adjacent muscles, as is usually the case in poliomyelitis, no definite conclusions can be drawn as to individual muscle action. For this, patients must be selected for study who have an isolated paralysis of one or two muscles, with all other muscles intact.

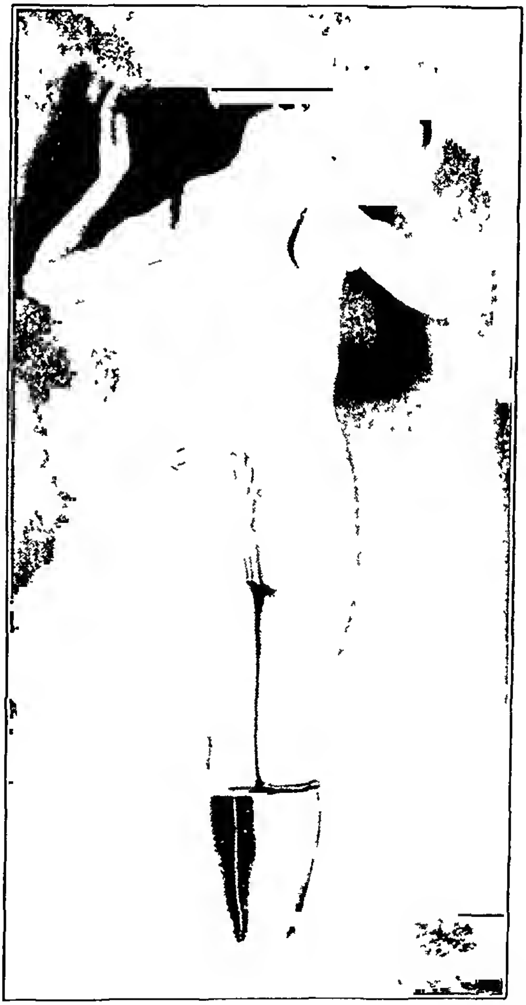


Fig. 1

From the standpoint of etiology, the seventeen cases

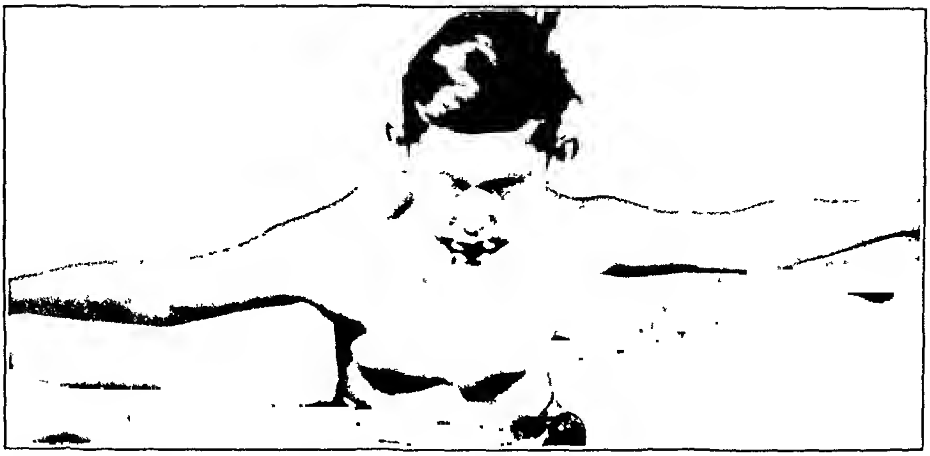


FIG. 2

chosen for the study are classified as follows: (1) injury or disease to the long thoracic nerve (one case), (2) injury to the spinal accessory nerve (four cases), (3) congenital muscular defects (seven cases), (4) muscle dystrophy (four cases), and (5) poliomyelitis (one case). These unusual types of shoulder palsy affect those muscles which connect the scapula and the clavicle with the main skeleton. These muscles have to do primarily with the movements of the scapula on the rib cage. They anchor the scapula to the trunk in all movements of the arm, rotating the scapula in whatever direction is required for the motion. Without these shoulder-blade fixators there is no control of the scapula, and the muscles acting on the arm become very inefficient.

The purpose of this paper is twofold: (1) To discuss positions and movements which to the greatest possible extent bring out isolated action of the shoulder-blade fixators and which make palpation of each muscle possible; and (2) to show by actual examples the functional disturbances which accompany isolated paralysis of these muscles.

To avoid misunderstanding, the following definitions are given:

Upward rotation of the scapula will mean that the glenoid cavity is turned upward while the inferior angle moves away from the spinal column.

Downward rotation of the scapula will mean the reverse movement of the above. In complete downward rotation the inferior angle of the scapula is closer to the spinal column than the superior; bilaterally, the vertebral borders of the scapulae form the letter V (Fig. 1).

Tipping forward of the scapula, that the coracoid process is lowered anteriorly while the inferior angle protrudes backward.

Trapezius

The various portions of the trapezius can easily be seen in normal subjects because they lie immediately under the skin. To bring out clearly the action of all parts of the trapezius simultaneously, one of the following tests is suggested:

1. Subject is in a sitting position with the trunk inclined forward

and the spine in a straight line; the arms are raised to a horizontal position with the elbows either flexed or extended (Fig. 2).

2. Subject lies face down with the arms abducted 90 degrees, the elbows either flexed or extended, and the arms raised off the floor.

3. Subject is in a sitting position with the hands on top of the head. The elbows are pushed backward against resistance (Fig. 3).

Any of these positions will reveal whether there is an absence or weakness of the trapezius as a whole or of one of its parts. The third test brings out most clearly the individual parts of the muscle. If any fibers of the lower and middle portion are present, they will contract vigorously when the subject attempts to push the elbows backward (Fig. 3). If the deltoid is weak, the resistance must be applied directly to the scapula.

When the whole trapezius is missing and the subject stands with arms hanging relaxed at sides, the scapula assumes a downward rotated position. The weight of the scapula and the arm, no longer supported by the trapezius, pulls down on the distal end of the clavicle, causing a considerable leverage action on the sternoclavicular joint. A subluxation of this joint is frequently the result (Fig. 4). An anterior view of a subject with involvement of the lower and the middle portions of the trapezius often shows a fold in the skin between the arm and the rib cage anteriorly to the axilla on the affected side. This skin fold is more pronounced in

FIG. 3

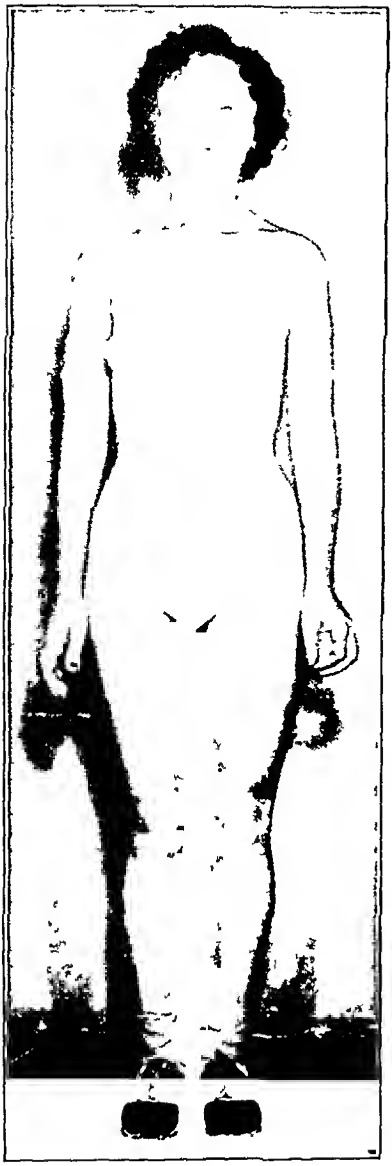


FIG. 4

subjects with well-developed adipose tissue. When the lower portion alone is missing, the skin fold may not be very noticeable, but there is always a tipping forward of the scapula, which causes the inferior angle to protrude. However, one must be careful not to conclude that all children with a protrusion of the inferior angle have an absence of the lower trapezius. This condition, when seen bilaterally, is most often a sign of poor posture; when present unilaterally, a lateral curvature of the spine may be the cause.

To test the upper portion of the trapezius separately, the subject is told to draw the shoulder toward the ear while slightly abducting the arm. In normal individuals, elevation of the shoulder girdle is accomplished through the combined action of the upper trapezius, the levator scapulae, and the rhomboids. The upward rotary action of the former muscle is counteracted by the downward rotary action of the two latter muscles. If the arm is somewhat abducted while the shoulder is raised, the rhomboids and the levator scapulae tend to relax, and the movement is performed mainly by the upper trapezius. Vice versa, the action of the levator scapulae is best studied when the shoulder is raised while the arm is adducted. By having the subject alternate these two movements (shoulder elevation with arm in abduction and the same movement with the arm in adduction), one can, through palpation, differentiate fairly well between these two muscles. If resistance is offered to the movement, both muscles contract in either case.

Absence of the upper portion of the trapezius causes a characteristic change in the outline of the neck and the shoulder which is particularly noticeable when the shoulder girdle is elevated. On such cases the levator scapulae can be seen in action directly under the skin. The posterior border of the distal end of the clavicle likewise can be seen, since it is not concealed by the trapezius, and the supraspinous fossa can easily be palpated (Fig. 5).

When the lower and middle portions are weak, the scapula cannot be

held in position when Test 1 is given (Fig. 2), and no resistance can be given in Test 3. If some fibers are still functioning, they can be seen contracting strongly (Fig. 3).

In all cases which were observed, partial or complete absence of the trapezius caused very little, if any, functional disturbance. Most subjects were unaware of any weakness and all movements could be performed without difficulty. The girl shown in Figure 3 had a complete absence of the upper trapezius, yet she displayed no difficulty in elevating the shoulder girdle. Surprisingly enough, when resistance was applied to this motion, it was found that the affected side was as strong as the unaffected. This girl had an almost complete absence of the middle and the lower portions as well. There was a very slight disturbance in the scapulohumeral rhythm, but the arm could be raised over the head without difficulty. Since the trapezius defect in this case was of long standing (possibly congenital), the girl had learned to compensate for the missing muscle with great success. The levator scapulae had taken over the function of the upper portion of the trapezius and the serratus magnus was able, without the aid of the trapezius, to perform the upward rotary movement of the scapula. Loss of the lower portion alone caused practically no functional disturbance. On the whole, the observation seems to indicate that the trapezius muscle is of less functional importance than is usually believed.

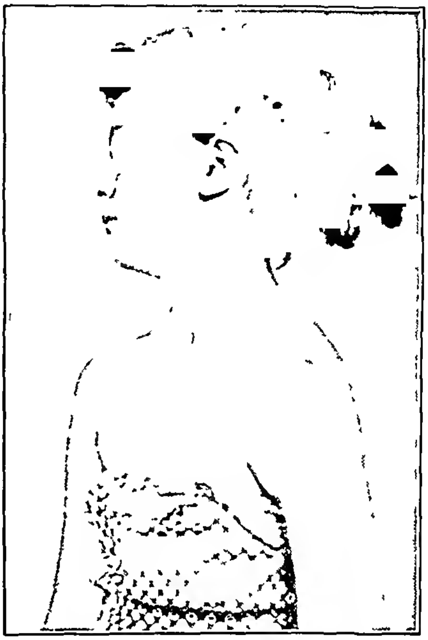


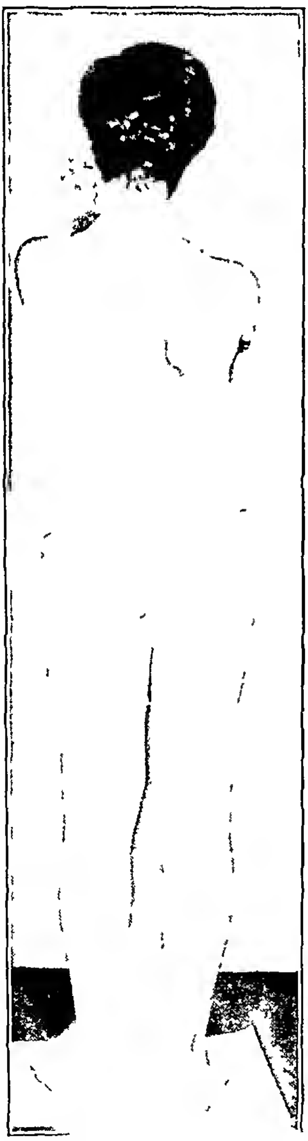
Fig. 5

Serratus Magnus

The anatomical position and shape of the serratus magnus makes observation and palpation of this muscle rather difficult. On thin subjects some of the lower digitations of the muscle can be seen at their origin on the ribs, but when much adipose tissue is present the muscle can be palpated only with difficulty. Pushing the shoulder and arm forward against resistance or complete abduction of the arm brings it into action. A subject with paralysis of the serratus magnus cannot raise the arm higher than to a horizontal position, either forward or sideward, even though the trapezius and the deltoid are functioning normally (Figs. 6 and 7). When attempting to do so, the whole vertebral border protrudes. There is no tipping forward of the scapula and the vertebral

border remains parallel to the spinal column. The trapezius provides a certain fixation of the scapula, but it is not able to rotate the scapula upward, hence the arm cannot be raised above a horizontal position. Pushing forward against resistance, as in assuming a prone falling position, further exaggerates the winging of the vertebral border of the scapula.

Observations of a number of cases with isolated paralysis of the serratus magnus indicate that no other muscle can take over its function. The pectoralis major muscle may draw the arm and indirectly the whole shoulder girdle forward, but the vertebral border of the scapula will protrude



unless the serratus magnus with its grip from the inside keeps the scapula flat on the rib cage. The rhomboids may assist in keeping the vertebral border of the scapula close to the rib cage, but these muscles have a downward rotary action on the scapula and, therefore, cannot substitute for the serratus magnus. The trapezius, which seems to have a good anatomical position for bringing about upward rotation of the scapula, does not do so to any considerable extent. The serratus magnus seems to be able to take over the function of the trapezius, but not vice versa. This makes us conclude that the latter muscle is by far the more important of the two.

In subjects lacking both trapezius and serratus magnus, there is no anchorage of the scapula and neither flexion nor abduction of the arm is very successful (Figs. 1 and 8). An attempt to raise the arm sideways brings about abduction of the humerus on the scapula through action of the deltoid, but the scapula rotates downward instead of upward. Since the scapula cannot be held firm, the deltoid pulls the acromion downward, and the weight of the arm also contributes to faulty rotation of the scapula. Complete absence of the upward rotators causes a very serious disability.

Fig. 8

Rhomboids

The rhomboid muscles, when the scapula is in an upward rotated position, pull the whole scapula, and in particular the inferior angle, toward the spinal column. When completing the downward rotary movement they also tend to elevate the shoulder girdle. These muscles are covered by the middle and the lower portions of the trapezius. They can easily be palpated, however, provided the trapezius

FIG. 9

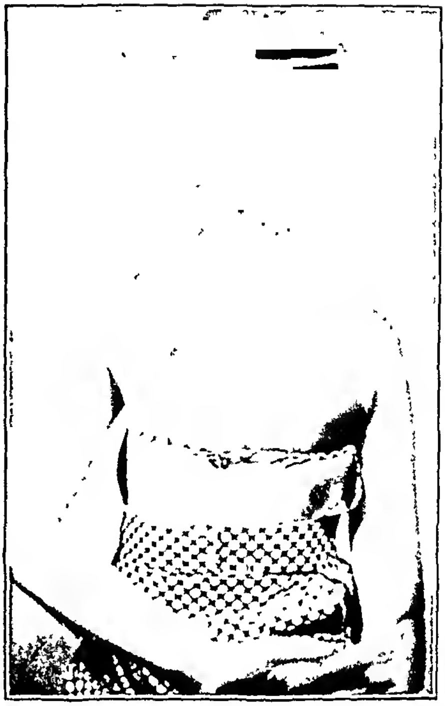


FIG. 10

is relaxed. To secure relaxation of the trapezius the subject should hyperextend the arm at the shoulder and place the hand across the back in the lumbar region. The examiner inserts the index finger or the ulnar border of the hand beneath the scapula (Fig. 9). This meets with no difficulty if the shoulder muscles are relaxed and some counterpressure is given from the front. The patient is then told to raise the forearm and the hand slightly away from the body (Fig. 10). This movement causes the rhomboids to contract powerfully, and the examiner's finger is pushed out from underneath the scapula. In all normal subjects the rhomboids can thus be palpated, but the muscle is most easily observed in subjects lacking the lower trapezius (Fig. 10). If the rhomboids are absent or weak, there is an empty space between the scapula and the rib cage and the fingers are not pushed out when the test is given. A subject with weak rhomboids may be able to raise the hand off the back, but with some difficulty, in which case the pectoralis minor tips the scapula forward. If there is an involvement of the posterior deltoid, the latissimus dorsi, the inward rotators of the arm or the flexors of the forearm, the examiner must support the arm and the forearm when the test is given.

If the rhomboids are weakened or completely paralyzed, and the arm is adducted against resistance, the scapula is pulled toward the arm by the teres muscles and fails to rotate downward. This test for the rhomboids should be given in addition to the test described above, since it presents a very typical picture. However, if the teres muscles are paralyzed as well, this latter test is of no value. Weakness or paralysis of the rhomboids is not noticeable in ordinary elevation and lowering of the arm

as gravity assists the downward rotation of the scapula. It is only when resistance is applied that a weakness becomes evident.

Paralysis of the rhomboids is fairly common in poliomyelitis, but other muscles are very likely to be involved at the same time. Isolated rhomboid paralysis or a congenital absence of the rhomboids has not been observed by the writer of this paper.

Pectoralis Minor

The pectoralis minor, originating from the third, fourth, and fifth ribs and inserting into the coracoid process, is covered by the pectoralis major. By pulling downward on the coracoid process the pectoralis minor tips the scapula forward, causing the inferior angle to protrude. In forced breathing the pectoralis minor comes into action, pulling upward on the ribs, and can be felt contracting, a test suggested by Bowen[1]. However, in this test one cannot prevent the pectoralis major from tightening up as well, which makes palpation of the pectoralis minor quite difficult. To eliminate the contraction of the pectoralis major the subject should assume the same position as that for testing the rhomboids (Fig. 9). The examiner places the finger tips just below and medial to the coracoid process. If the subject is cooperative and able to relax, the examiner can insert the fingers quite deeply and can reach almost underneath the coracoid process without causing the subject any discomfort. When thereafter the subject raises the forearm off the back, the pectoralis minor comes into vigorous contraction and the fingers are pushed out from underneath the coracoid process by the contracting muscle. By palpating the rhomboids and the pectoralis minor simultaneously, it can be determined whether the tipping forward of the scapula is performed by the pectoralis minor alone, or by the rhomboids alone, or whether both muscles participate. Isolated paralysis of the pectoralis minor has not been observed by this writer.

Levator Scapulae

This muscle is most easily palpated in subjects lacking the upper trapezius (Fig. 5). The almost vertical fibers of the levator scapulae, as compared to the more oblique fibers of the upper trapezius, make it possible to distinguish between the two muscles in normal individuals also. When the shoulders are shrugged, the levator scapulae can be felt behind the sternocleidomastoid muscle in the posterior triangle of the neck. A fairly good relaxation of the upper portion of the trapezius is obtained if the subject presses the arm against the side while elevating the shoulder girdle.

The levator seems to be perfectly able to take over the function of the upper trapezius when this muscle is paralyzed. Whether or not the opposite is also true—that is, whether the upper trapezius is able to elevate the shoulder girdle against resistance in case of paralysis of the levator scapulae—cannot be learned from the present study. No cases were observed with this type of paralysis.

SUMMARY

1. A study of seventeen cases of isolated paralysis of the shoulder-blade fixators was undertaken in order to determine the relative importance of each of these muscles in arm movements.

2. Tests for individual muscles are described.

3. Isolated paralysis of the trapezius, even in cases where the whole muscle is absent, does not interfere appreciably with the elevation of the arm. The disability is marked only when the subject abducts the arm with the trunk inclined forward.

4. Isolated paralysis of the serratus magnus causes far more disability than paralysis of the trapezius alone, as the subject is unable to elevate the arm above a horizontal position.

5. Paralysis of both the trapezius and the serratus magnus causes a very serious disability. The scapula completely lacks fixation, and abduction of the arm can be performed to approximately 60 degrees only.

6. Isolated paralysis of the rhomboids or the pectoralis minor was not present in any of the cases studied. The exact effect of the loss of one of these muscles, therefore, could not be determined. In cases with weak rhomboid muscles, resistive adduction of the arm proves to be rather difficult, as the teres major pulls the scapula toward the arm instead of pulling the arm toward the scapula.

7. Isolated paralysis of the levator scapulae was not found in any of the cases studied. When the upper trapezius is absent and the rhomboids weak, the subject has no difficulty in elevating the shoulder girdle against resistance. It seems, therefore, reasonable to assume that in normal subjects, too, the levator scapulae is the most important muscle for elevation of the shoulder girdle.

8. The etiology could not be determined with certainty in all cases, but five groups were recognized: injury to the long thoracic nerve, injury to the spinal accessory nerve, congenital defects, muscle dystrophy, and poliomyelitis.

1. Bowen, W. P.: Applied Anatomy and Kinesiology; The Mechanism of Muscular Movement. Ed. 4. p. 76. Philadelphia, Lea & Febiger, 1928.

EARLY REPAIR OF BONE: AN EXPERIMENTAL STUDY OF CERTAIN FACTORS *

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The textbook description of reparative changes following fracture of bone focuses the attention of the student on the site of the fracture to the exclusion of all other regions. Almost invariably an outpouring of blood and connective-tissue cells from the medullary cavity and cortex is described, together with an associated proliferation of the periosteum and adjacent soft tissues. The blood clot then becomes infiltrated with fibroblasts, which undergo cytological changes from the cartilage stage to formation of adult bone. Certain of these changes do occur, but the earliest and most marked reactions frequently take place not only at the site of fracture, but along the entire shaft as well.

The authors' attention was drawn to this fact in the course of certain experiments which were undertaken to investigate the stimulating effect of embryonic chick extract on repair of fractures. The microscopic appearances noted stimulated them to make a more exhaustive study.

METHOD OF STUDY

Twenty-one mature female rats, each five months of age and weighing about 200 grams, were used. The right humerus of each rat was fractured under anaesthesia at the junction of the middle and lower thirds by the method described in a previous article.[1] Retentive apparatus was not used to immobilize the limb. The rats were arranged in three groups. Group A consisted of seven normal rats in which the humerus was fractured. Group B consisted of seven rats which had been spayed two months previously. Vaginal smears made prior to fracture of the humerus indicated an absence of estrogenic substance in the circulation. The rats of Group C corresponded in all details to those of Group B except that each rat received 2000 international units of estrogenic substance on the second, fourth, and sixth days following fracture.

One rat of each group was killed at daily intervals following fracture. The humeri were removed and preserved in a 10-per-cent. solution of formalin prior to decalcification. Thereafter, the bone was prepared in the usual manner for microscopic examination.

Careful and repeated microscopic examinations of the sections removed from the first to the seventh postoperative day indicated that the

* The work was done at the Institute of Experimental Medicine under the supervision of G. M. Higgins, M.D.

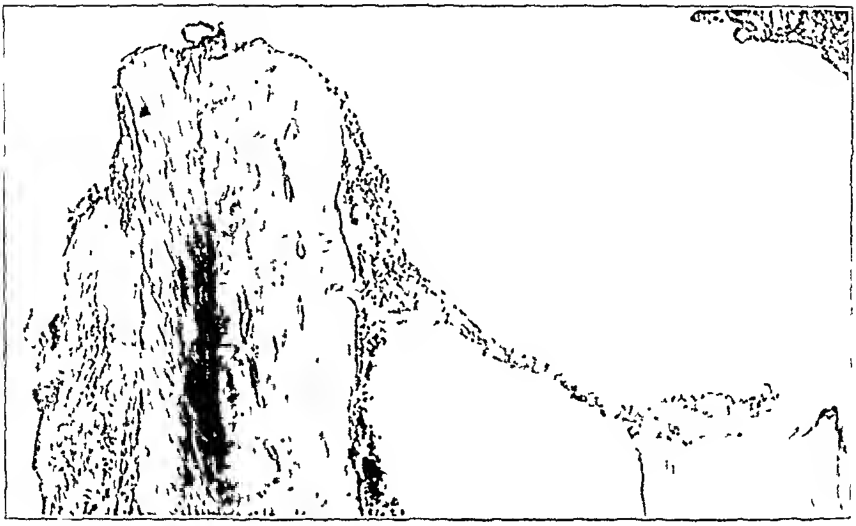

FIG. 1

Photomicrograph (× 50) of tissue obtained on the first postoperative day from a spayed rat which had received estrogenic substance, shows a fibrinous suspension bridge stretched across the medullary cavity from the periosteum on one side to the periosteum on the other.

rate of formation of new bone, especially the endosteal bone, was increased among the rats in Group C which had been given estrogenic substance. In an attempt to demonstrate this formation of new bone satisfactorily a new series of rats, comparable in age and weight to those of Groups A, B, and C, received injections of a 1-per-cent. solution of alizarin prior to and subsequent to operative fracture of the right humerus. Specimens of bone were removed at daily intervals and filed down on the microtome, as this was the only way satisfactory sections could be procured.

In the rats of the last group, a definite zone of formation of new bone, as revealed by the pink coloration of alizarin, appeared four days after fracture. The solubility of the dye makes permanent preparations of sectioned material unsatisfactory, and some other method, therefore, is required to demonstrate grossly the extent of formation of new bone satisfactorily.

MICROSCOPIC FINDINGS

The first specimens, which were examined twenty-four hours after the humeri were fractured, revealed the presence of hemorrhage in the soft tissues. At this early stage a definite capsule uniting the fractured ends of bone was not present. Microscopically, the medullary cavity was isolated by a delicate cellular structure similar to a suspension bridge, which was continuous across the region, joining the periosteum on the two sides (Fig. 1). This structure, when seen under a high-power lens, was found to consist of interlacing strands of fibrinous material containing lymphocytes, leukocytes, and plasma cells (Fig. 2). A fact of some significance, perhaps, was the absence of a corresponding number of red blood corpuscles.

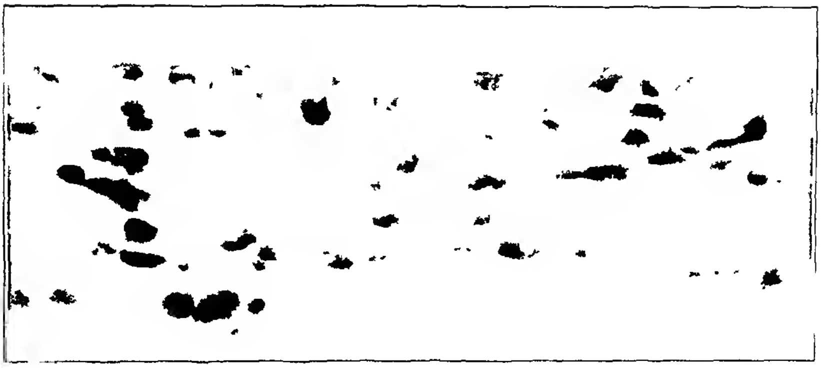

FIG. 2

Photomicrograph (× 600) of tissue obtained on the first postoperative day from a spayed rat which had received estrogenic substance, shows lymphocytes and plasma cells enmeshed in the middle of the fibrinous bridge.

In all probability the bridgelike cellular structure was formed from fibrin, but its appearance suggested that it was composed of matrix, in which red blood cells could develop. In other sections strands of periosteum extended across the medullary cavity, thereby acting as a seal. Along the sides of the shaft the periosteum was normal and firmly adherent to the underlying bone.

The gross appearance of the specimens removed two days after the bone was fractured was similar to that just described, but in addition the soft tissues immediately adjacent to the fractured ends had a whitish, rather glistening appearance, were attached to the ends of the bone, and seemed to act as a capsule. This tissue was extremely delicate and could be torn easily.

Microscopic examination of tissue removed on the second postoperative day demonstrated cytological features at the site of the fracture, similar to those found twenty-four hours after fracture (Fig. 3). The most pronounced change was the increased thickness of the periosteum of the entire bone, which was as marked near the surgical neck as it was at the site of the fracture. It appeared as though some circulating stimulant had resulted in general periosteal hyperplasia.

Sections of bone removed from the spayed rat indicated that a small fragment of the cortex had become detached and acted as a plug in the medullary cavity (Fig. 4), sealing it effectively. The question arose as to whether fusion between this hard cortical plug and the adjacent cortex could lead to subsequent non-union.

Three days after fracture there was little change in the gross appearance of the specimens from that found on the second postoperative day. Microscopically, however, the fibrinlike seal covering the medulla was thicker, and apparently invaded by fibrous-tissue cells which had extended into the marrow. These sections demonstrated well the continuity of this organized plug with the surrounding periosteum (Fig. 5). The periosteum was markedly thickened, and at positions well removed

FIG. 5

Photomicrograph (× 35) of tissue obtained on the third postoperative day from a rat which was normal except for fracture, shows the sealing of the medulla, the covering of which now appears to be organized, to be more marked than in Fig 3. Its continuity with the much thickened periosteum, and early osteoid formation under the periosteum, and a trace of beginning osteoid formation in the endosteum can also be seen.

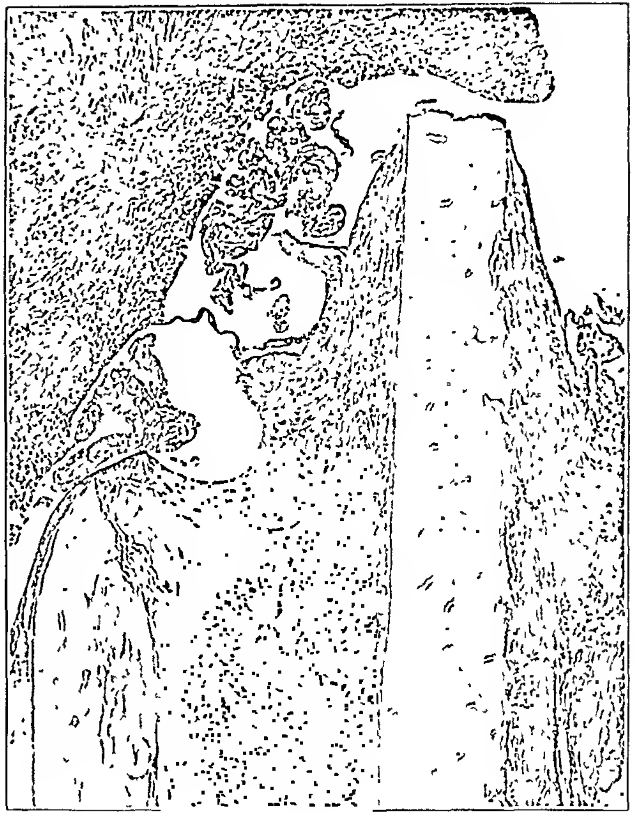

FIG. 6

Photomicrograph (× 30) of tissue obtained on the sixth postoperative day from a rat which was normal except for fracture, shows a marked degree of subperiosteal formation of new osteoid tissue just below the surgical neck. Formation of new bone within the region well removed from the site of the fracture can be seen.

from the site of injury it revealed the presence of young osteoid tissue (Fig. 6). At the site of the fracture the soft tissues had been infiltrated by round cells and leukocytes; young blood vessels had made their appearance in the marrow and it seemed that a concentration or perhaps proliferation of megakaryocytes in these regions had also taken place. Young osteoid tissue had developed from the endosteum and stretched down toward the extremity of the bone.

The sections prepared from the specimens removed four days following fracture of the humerus were similar to those described previously, but in a slightly more advanced stage of development. In addition, a few osteoclasts were seen at the ends of the bone. Osteoid tissue was not present between or in the soft tissues adjacent to the fractured ends.

By the fifth day a fairly well-developed capsule united the ends of the bone. This capsule had a whitish, glistening appearance, and was much more tenacious than that described in the specimen removed two days after fracture. Subperiosteal osteoid tissue developed at sites well removed from the fracture and small islands of young cartilage appeared, but they were secondary in size and date of origin to the osteoid tissue.

Well-developed endosteal bone rapidly sealed the medullary cavity, and in relation to it young blood vessels were seen in the marrow. Osteoclasts or fused bone cells liberated from the fragmented ends of bone also were present.

The specimens removed on the sixth postoperative day revealed further development of the features just described (Fig. 6). Subperiosteal and endosteal formation of new bone was marked, and in the former the development of cartilage was recognized. A more definite sealing of the medulla was noted and in the surrounding tissues a reversal to a more embryonic type of cell was apparent.

By the seventh postoperative day the ends of bone were united by a comparatively tough capsule composed of closely packed and elongated fibroblasts. In some instances this capsule was bilocular, as it was divided by a central septum into two cavities, each one adjacent to the fractured end of one of the fragments of bone but separated from its medullary cavity by the endosteal plug. The cavities contained a network of interlacing fibers, the interstices of which were filled with amorphous débris. The walls in certain regions disclosed the presence of myxomatouslike cells. When the walls were cut, a sanguineous fluid exuded from the cavities. It is possible that within this capsule nature has developed a small chemical factory in which the hydrogen ion is controlled and bone is developed.

The development of subperiosteal and endosteal osteoid was well demonstrated in all the sections made on the seventh postoperative day.

COMMENT AND CONCLUSIONS

Scaling of the medullary cavity appears to be one of the first steps in the healing of a fracture. This may be produced by (1) a strand of peri-

osteum, (2) a band of fibrin, or (3) a fibrinouslike plug produced by mass destruction of the red corpuscles. The seal is continuous across the cortex with the periosteum, and later becomes infiltrated by fibrous-tissue cells from this membrane. In other cases, however, these cells may arise from the marrow or develop directly from the lymphocytes caught in meshes of this fibrinous medullary cap.

By the second day, the periosteum from the site of fracture to the neck of the humerus is thickened. This would appear to be the result of a general stimulation rather than that caused by local trauma. By the third day, osteoid tissue has developed subperiosteally in regions well removed from the fracture. At the same time, osteoid tissue which has arisen from the endosteum, has also made its appearance at the fractured ends of the bone and, in conjunction with the original fibrinous plug, formed a more efficient seal for the medullary cavity. The development of this subperiosteal bone along the entire shaft was one of the most interesting features of this study.

The authors were not able to demonstrate any appreciable differences in the early stages of repair of bone in the three groups, but gained the impression that injections of estrogenic substance stimulated production of endosteal osteoid tissue. The insertion into the medullary cavity of a small plug of dense cortical bone as occurred in one of the cases could predispose to non-union.

1. Pollock, G. A.: The Effect of Theelin on Fracture Repair. Proc. Staff Meet., Mayo Clinic XV, 209, 1940.

LONGITUDINAL FISSURES IN THE VERTEBRAL ARTICULAR PROCESSES

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Radiolucent gaps in the neural arch and its processes are known to be due to persistence of cartilaginous union and failure of bony union between parts which arise from distinct centers of ossification. Most of these so-called fissures are in the laminae, in the isthmus between the superior and inferior articular processes, and at the tip of the inferior articular processes of the lumbar vertebrae. An additional fissure, apparently not yet recorded, was found in four persons. In each of them, it was associated with gaps at the tips of the articular process and, in one patient, with gaps in both the isthmus and the lamina of the same vertebra. It extended from the region of the isthmus along the longitudinal axis of the articular process down to the gap at its tip, the

FIG. 1-A

FIG. 1-B FIG. 1-C

Anteroposterior (Fig. 1-A) and oblique (Fig. 1-B) views of the mid-lumbar region of a man, aged thirty-two, examined for hematuria. The right third inferior lumbar articular process has a gap at its tip and a longitudinal fissure with irregular outlines. The two gaps are retraced for better demonstration in Fig. 1-C. There are no symptoms referable to the spine, or any history of trauma.

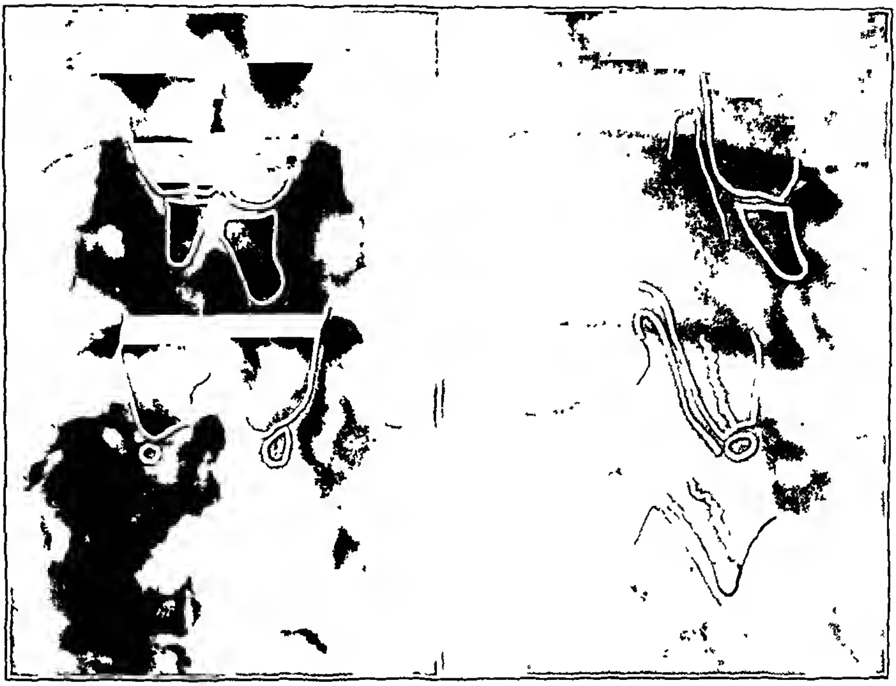

FIG. 2-A FIG. 2-B

Anteroposterior (Fig. 2-A) and oblique (Fig. 2-B) views of the lower lumbar region of a man, aged sixty-four, examined for a tumor in the epigastrium. There were no signs or symptoms of vertebral disease, and no history of trauma. Note gap formations in the inferior articular processes of the third and fourth lumbar vertebrae, with longitudinal fissures (outlines retraced).

two fissures standing at right angles (Figs. 1-A, 1-B, and 1-C). In all the cases the outlines of the longitudinal fissure were irregularly serrated, which suggested a fracture line. None of the patients, however, remembered having incurred an injury, and there were no signs or symptoms whatever referable to the spine. The gaps were discovered accidentally in roentgenograms of the digestive or urinary tract. Since there is only one center of ossification for the main part of each articular process, according to present knowledge, it would seem difficult to account for the longitudinal gap by a developmental failure of bony union. However, the constant combination with a second gap known to be due to such a failure, together with the absence of a history or clinical signs of trauma, is in favor of a developmental anomaly. These longitudinal fissures are rare, their incidence being in our observations as low as that of aplasia of articular processes,—namely, 0.09 per cent. of all spines examined.

The sole significance of the longitudinal gaps would seem to lie in the fact that they look like fracture lines. Fractures of the articular processes are rare, most of them being combined with fractures of other parts of the vertebrae. The writer has observed only three cases of fracture of an articular process without other vertebral lesions; in each of them, the clinical signs and symptoms were definite and the trauma had been severe. Two of them had radicular neuritis with atrophy of the corresponding

muscles and bone, and in all the cases the mobility of the spinal section involved was greatly diminished. The fact that a longitudinal fissure resembling a fracture line may exist in the complete absence of clinical manifestations may be worth recording, since increasing importance is given to roentgenographic findings in deciding on questions of treatment and of compensation after some relatively slight injury. One may easily be inclined to ascribe symptoms to such a formation, when they are perhaps due to some other cause,—for instance, to a simple strain or a post-traumatic neurosis.

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CALCIFICATION AND OSSIFICATION

II. Control of Calcification in the Fracture Callus in Rachitic Rats *

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FRANKLIN C. MCLEAN, M.D., CHICAGO, ILLINOIS

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In the preceding paper [20] we have described the progress of calcification in the fracture callus of normal rats. For the purpose of analyzing the process of calcification, observations upon normal animals have definite limitations. Calcification occurs simultaneously with osteogenesis,‡ and there is no possibility of controlling it, or of observing the processes of osteogenesis and of calcification separately. To a very considerable degree these difficulties are avoided in the case of low-phosphate rickets. If this form of rickets may be regarded as primarily a phosphate deficiency [13] the results obtained may be safely transferred to the interpretation of processes occurring under more normal conditions. Calcification and healing can be induced in low-phosphate rickets in the rat by the administration of phosphates; and the healing so obtained is comparable with that produced by the administration of vitamin D [12].

I. HEALING FRACTURES IN UNTREATED FLORID RICKETS

Experimental studies concerned with the relationship of diet to the healing of fractures have been reviewed by Goisman and Compere. Erdheim; Downs and McKeown; Ham, Tisdall, and Drake; and Compere, Hamilton, and Dewar have described decalcified histological preparations of healing fractures in rachitic animals. Pappenheimer observed fractures in rachitic rats, in sections stained by the von Kóssa method after partial decalcification in Müller's fluid.

Rats were weaned to the Steenbock-Black rachitogenic diet No. 2965 at the age of twenty-one days and were given fractures at the age of seven weeks. The animals were sacrificed at daily intervals from one to fifteen days following the fractures and at two-day intervals thereafter. The series of preparations includes the bones of five litters of rats with florid rickets and the fractures in untreated rachitic rats used as controls in

* This work was aided by a grant from the Josiah Macy, Jr., Foundation.

† Henry Strong Denison Scholar for 1940–1941.

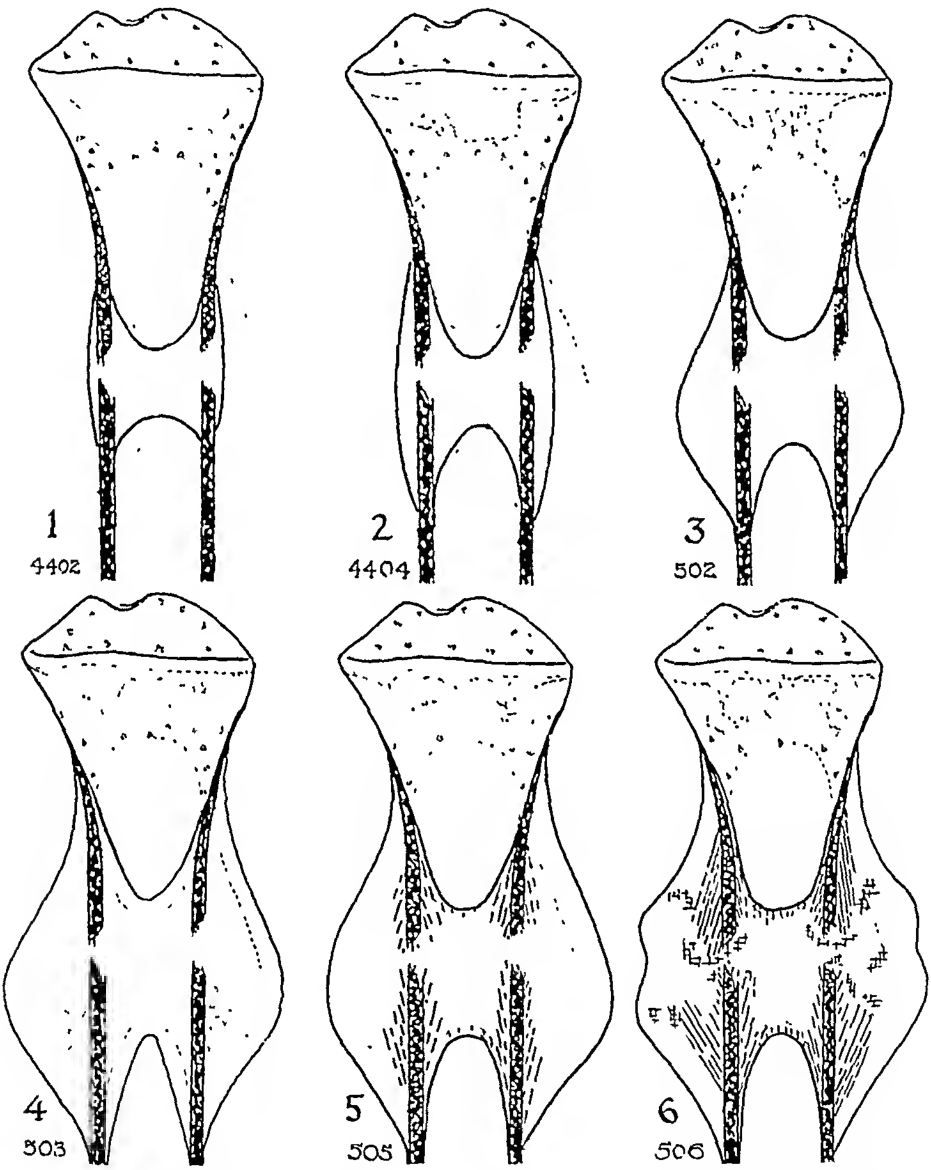
‡ Properly speaking the terms osteogenesis and ossification include the calcification which is an essential part of the formation of bone. In order to avoid confusing circumlocutions we have at times separated these meanings, so that osteogenesis and ossification are used to designate the formation of osseous tissue, without regard to its state of calcification. Similarly we have used the terms osteocyte, osteoblast, and osteoclast to designate particular types of cells, without reference to whether the osseous tissue with which they are associated is calcified or not.

twenty other experiments. The techniques employed in this study were those previously described [20].

In rachitic rats the healing of fractures begins as it does in normal rats [20] with the important difference that the healing process proceeds in

FIGS. 1–18

Figures 1–18 are diagrammatic representations of deposits of bone salt in rachitic bones with healing fractures.†

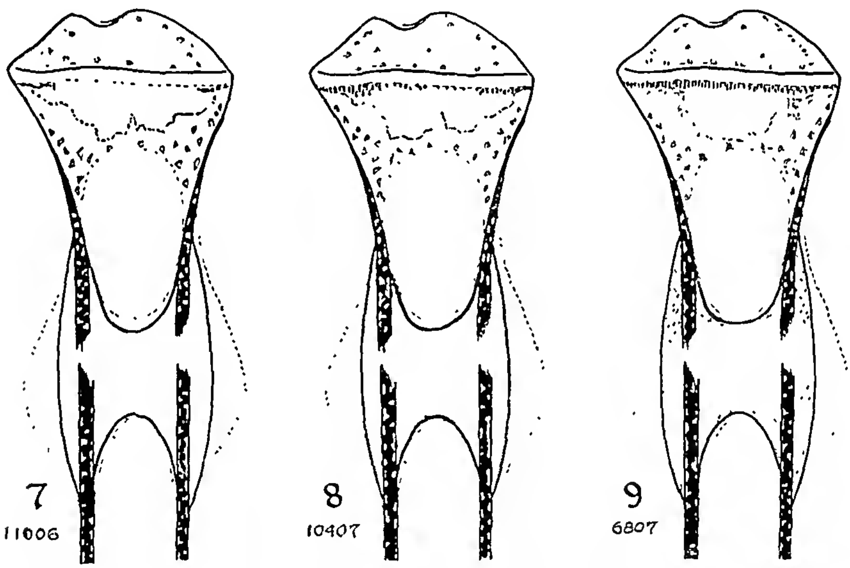


Healing fractures in untreated rickets. Fig. 1: after two days; Fig. 2: four days; Fig. 3: eight days; Fig. 4: twelve days (note beginning spontaneous calcification in subperiosteal and subendosteal osteoid); Fig. 5: twenty days; and Fig. 6: non-union at twenty-eight days, with considerable spontaneous calcification in the callus and none in the epiphyseal cartilage or metaphysis.*

† For similar diagrams of healing fractures in normal rats, see Urist and McLean [20].
* See key on page 285.

the complete absence of calcification of the newly formed tissues for the first ten to fifteen days following the injury (Figs. 1, 2, 3, 20, 27, and 31). There is the same initial inflammatory response to the injury, resulting in the formation of the fibrocartilaginous callus in and around the fracture line. There is the same formation of osseous tissue under the periosteum and the endosteum, beginning at some distance from the fracture line, elevating these membranes, and advancing toward the callus mass. In the early stages of healing the osseous tissue is indistinguishable from similar tissue formed in the animal on normal diet, unless stained to detect the absence of calcification.

The differences in the reaction of the rachitic animal to a fracture from those of a normal animal with a similar injury, exclusive of the state of calcification, begin to be apparent by about the fourth to the fifth day following the fracture. At this time, in the normal animal, the new intramembranous bone, formed under the periosteum and the endosteum, has



Healing fractures in rickets four days after fracture following a single dose of one-tenth molar of phosphate solution, 2.5 cubic centimeters per 100 grams body weight. Fig. 7: four hours after administration of phosphate; Fig. 8: twelve hours; Fig. 9: twenty-four hours. Note increasing calcification in epiphyseal cartilage and beginning calcification in subperiosteal and subendosteal osteoid.*

*  Normal shaft

 Osteoporotic shaft

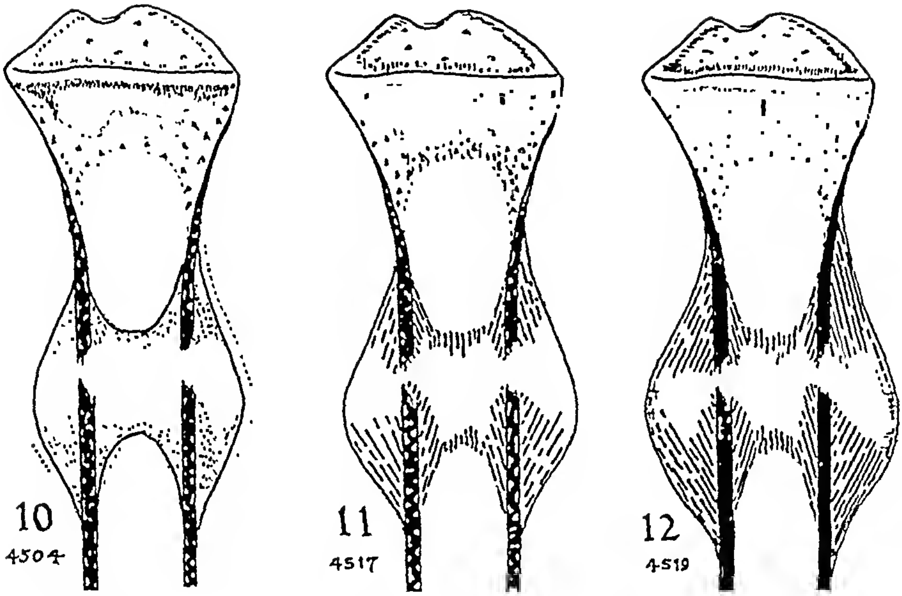
 Spongy bone

 Beginning calcification

 Calcified cartilage

 Old calcified trabeculae with osteoid borders.

Light broken lines represent the usual limits of epiphyseal bone, epiphyseal cartilage, rachitic cartilage, and chondro-osteoid, spongiosa, and fracture callus, respectively.



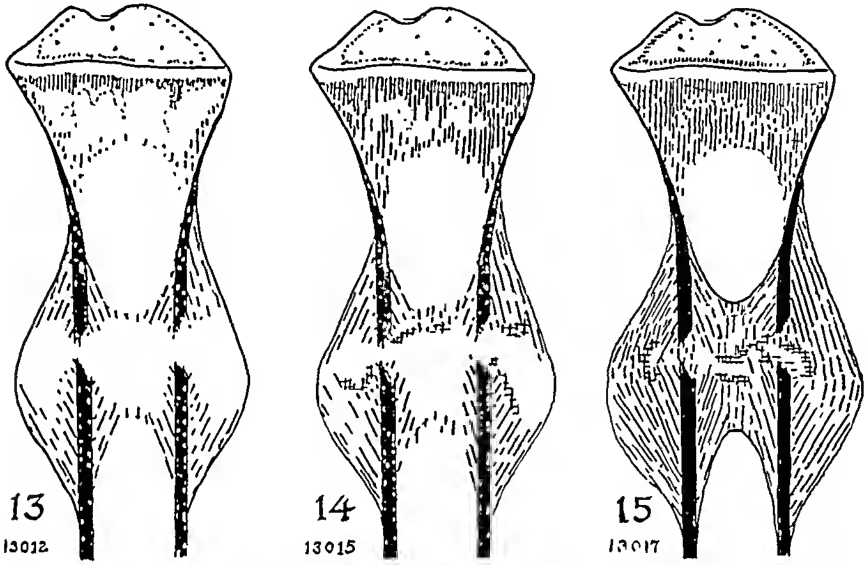
Healing fractures after daily doses of phosphate, beginning with the fourth day of healing. Fig. 10: after five days of healing; Fig. 11: eight days; Fig. 12: twelve days. Note increasing calcification in callus, metaphysis, and epiphyseal cartilage.*

gained contact with the fibrocartilaginous callus, and removal of the latter with its replacement by bone is well under way. The fibrocartilaginous callus consists at this time of undifferentiated dense connective tissue, of fibrocartilage, and of hyaline cartilage in various stages of development. All of these tissues, in the normal animal, are invaded by the new osseous tissue with equal ease, and their removal proceeds over a wide front with some differences in detail according to the tissue being invaded. At the same time, in the rachitic animal, the callus consists of the same tissues, and is microscopically indistinguishable from the callus in the normal animal. There is, however, in the rachitic animal, a marked lag in the processes of replacement of the callus tissues by the newly formed osseous tissue, and the details of this difference in behavior, and of its correction when treatment leading to deposition of bone salt is instituted, indicate the degree to which the processes in the normal animal are dependent upon the orderly progress of calcification.

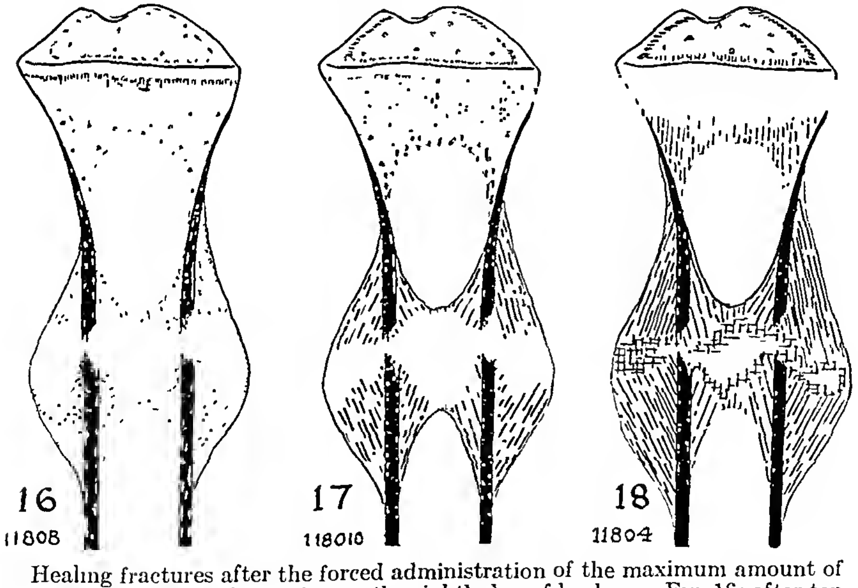
Park has described the process of cartilage removal in the rachitic rat as an invasion of the cartilage by capillary "bushes", leading to its replacement by uncalcified "pseudo-osteoid". In rachitic animals, as in normal animals, there are invasion and replacement of the epiphyseal cartilage plates. The essential difference in rickets is that, in addition to the failure of the cartilage matrix to calcify, invasion by the capillary "buds" or bushes occurs over a front of several rows of cartilage cells together, instead of invasion of the rows singly. Also, instead of only cartilage matrix, stripped of its cells, being left, there are columns of cartilage, of varying widths and thicknesses, in which cartilage cells persist.

* See key on page 285.

As in normal intracartilaginous ossification, there is apposition of osseous tissue upon a framework of tissue derived from the epiphyseal cartilage. In rickets this tissue is uncalcified osteoid, and it is laid down upon the persisting remnants of cartilage which, as stated above, include cartilage cells. The result is that the rachitic metaphysis is made up of uncalcified trabeculae, which include cells with the arrangement and some of the



Healing fractures after daily doses of phosphate, beginning with the eighth day of healing. Fig. 13: after ten days of healing; Fig. 14: sixteen days; Fig. 15: partial union at twenty-four days.*



Healing fractures after the forced administration of the maximum amount of phosphate tolerated, beginning on the eighth day of healing. Fig. 16: after ten days of healing; Fig. 17: eleven and one-half days; Fig. 18: twelve and three-quarters days. Note rapid increase in calcification.*

* See key on page 285.

morphological characteristics of the epiphyseal cartilage cells, and which are encased in osteoid. The fate of these cartilage remnants has been considered in detail by Dodds and Cameron and need not

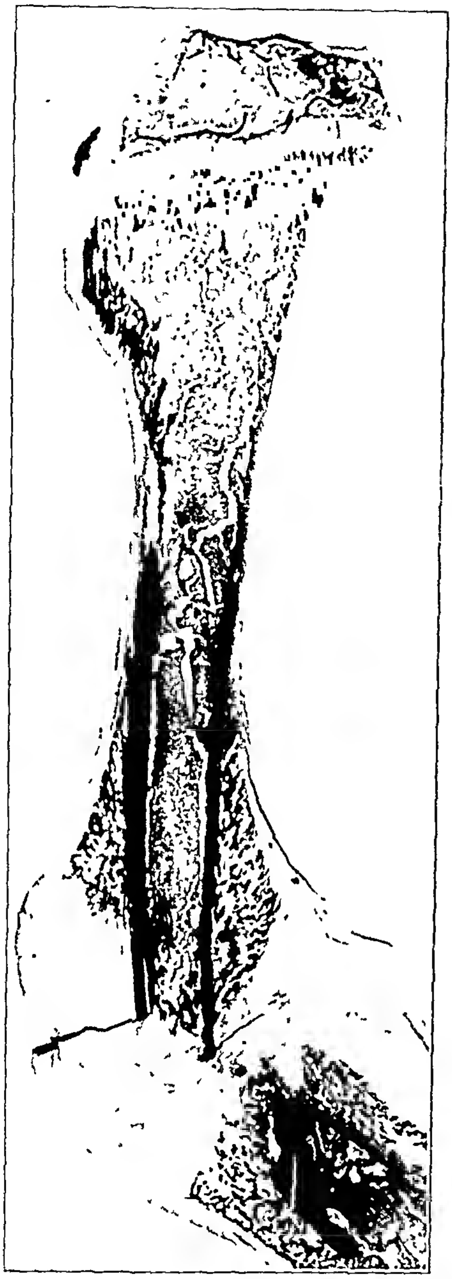


FIG. 19

Photomicrograph (× 8) of longitudinal section through undecalcified tibia, ten days after fracture, of a rat, fifty-nine days of age, which was weaned at twenty-one days to Steenbock-Black rachitogenic diet No. 2965 supplemented by 2-per-cent. cod-liver oil. The epiphyseal cartilage appears somewhat wider than normal. There is delay in calcification in the epiphyseal cartilage, metaphysis, and subperiosteal new bone. Silver nitrate-hematoxylin-eosin stain was used in this and the following specimens.

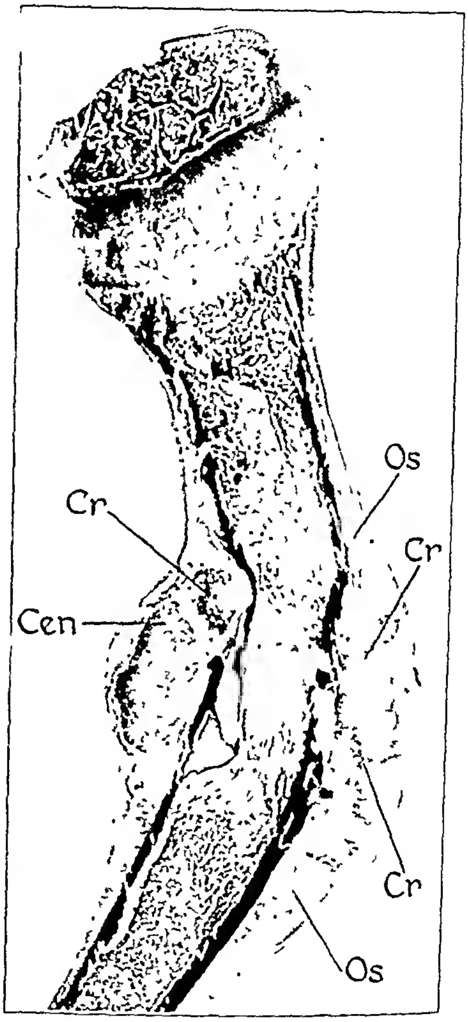


FIG. 20

Photomicrograph (× 8) of longitudinal section through undecalcified tibia, ten days after fracture, of a rat, fifty-nine days of age, which was weaned at twenty-one days to Steenbock-Black rachitogenic diet No. 2965. There is complete absence of calcification in the epiphyseal cartilage, metaphysis, and callus. *Cr*, cartilage in process of removal, rachitic type; *Cen*, partially encapsulated cartilage, not being removed; *Os*, subperiosteal osteoid, in contact with callus cartilage.

be described here. The rachitic metaphysis as a whole is a mixture of uncalcified tissues derived from cartilage and from the osteogenic cells of the advancing bone marrow. This tissue was called "chondro-osteoid" by von Recklinghausen and we shall use the term for this atypical tissue arising in both the metaphysis and the callus.

The process, just described, of intracartilaginous ossification from the epiphyseal cartilage, is duplicated in the callus cartilage in rachitic animals (Fig. 31). But, just as there is a delay of some days [4] in the initiation of this process in the epiphyseal cartilage following the onset of rickets, so there is a lag in its initiation in the callus of the rachitic animal. Under the most favorable conditions for its initiation and progress, which are that the new intramembranous osseous tissue is in contact with the hypertrophic cartilage, the growth of buds or bushes into the callus cartilage does not begin until about the ninth or twelfth day after the fracture. From this time on the process may progress rapidly, eventually leading to complete replacement of the callus cartilage with chondro-osteoid, and to actual union across the fracture line. The picture, however, is complicated by the occurrence of spontaneous calcification as described below.

In many instances, there is an additional factor which further complicates and delays the process of replacement of the callus by osseous tissue. It has been stated above that in normal animals the new osseous tissue invades undifferentiated fibrous tissue, fibrocartilage, and hyaline cartilage with equal ease. Consequently when fibrous tissue or fibrocartilage lies between the advancing bone and the hyaline cartilage of the callus, this intervening tissue is early replaced by bone, and offers no barrier to the advance of the osseous tissue. In the rachitic animal, however, invasion of connective tissue or of fibrocartilage, if it occurs at all, is accomplished slowly and after considerable delay. During the period of delay incident to the invasion of the callus cartilage, the latter frequently becomes embedded—one might almost say encapsulated—in dense connective tissue and fibrocartilage (Fig. 20). This encapsulation not only forms a barrier to the replacement of the callus cartilage by osteoid tissue, but it also forms a barrier to the resumption of the normal healing process when calcification of the callus is instituted by suitable means. This latter influence of the encapsulation of the callus cartilage is considered in detail in the following sections.

Spontaneous Calcification in the Callus

The processes just described, in the absence of calcification, tend toward the union of the fracture by the formation of a callus composed of osteoid tissue. Before this point is reached, however, the process is modified by the deposition of bone salt in the callus.

As stated above, the callus in florid rickets is characterized by a complete absence of bone salt during the first ten to fifteen days of its development. At about this time, however, there appeared regularly in our experiments (Figs. 4, 5, and 6) a beginning calcification in the osteoid of

TABLE I

INITIATION OF CALCIFICATION IN THE EPIPHYSEAL CARTILAGE, METAPHYSIS, CALLUS OSTEOID, AND CALLUS CARTILAGE IN RACHITIC RATS, FOLLOWING INTRAPERITONEAL ADMINISTRATION OF A SINGLE DOSE OF M/10 PHOSPHATE MIXTURE, 2.5 CUBIC CENTIMETERS (7.5 MILLIGRAMS PHOSPHORUS) PER 100 GRAMS OF BODY WEIGHT

Group	Number of Days of Healing	Total Number of Days on Diet	Number of Hours after Injection	New Calcification			
				Epiphyseal Cartilage	Metaphysis	Callus Osteoid	Callus Cartilage
A	0	28	0	−	−		
	0		8	−	−		
	0		24	+	−		
	0		24	+	−		
B	3	31	0	−	−	−	−
	3		4	−	−	−	−
	3		8	−	−	−	−
	3		12	+	−	−	−
	3		24	+	+	+	−
C	4	32	0	−	−	−	−
	4		4	−	−	−	−
	4		8	−	−	−	−
	4		10	−	−	−	−
	4		12	−	−	−	−
	4		14	+	−	−	−
	4		24	+	+	+	−
D	5	33	0	−	−	−	−
	5		1	−	−	−	−
	5		2	−	−	−	−
	5		3	−	−	−	−
	5		4	+	−	−	−
	5		5	+	−	−	−
	5		6	+	+	−	−
	5		8	+	+	+	−
E	7	35	0	−	−	−	−
	7		14	−	−	−	−
	7		24	+	±	+	−
F	8	36	0	−	−	−	−
	8		0	−	−	−	−
	8		0	−	−	−	−
	8		24	+	±	+	−
G	10	38	0	−	−	+	−
	10		0	−	−	+	−
	10		0	−	−	+	−
	10		4	−	−	+	−
	10		12	−	−	+	−
	10		24	−	−	+	−
	12	40	4	−	−	+	−
	12		8	−	−	+	−
	12		24	−	−	+	−
H	12	41	0	−	−	+	−
	15	43	0	−	−	++	−
	15		0	−	−	++	−
I	16	44	0	−	−	++	−
	20	48	0	−	−	++	±
	26	54	0	−	−	+++	+
	28	56	0	−	−	+++	++

days following a fracture and thirty-eight days on the rachitogenic diet it was more difficult to initiate calcification in the epiphyseal cartilage (Fig. 27). Later, frequently after fifteen days, there appeared spontaneous calcification in the callus osteoid. The density of the deposit in the callus

osteoid increased up to twenty-eight days following the fracture, and in animals examined twenty-six and twenty-eight days after a fracture there was also spontaneous calcification in the matrix of the callus cartilage.

In one litter of rats (Group D, Table I) the bones were studied by means of unfixed, hand-cut, quick-stained (10-per-cent. silver nitrate) sections. In these preparations calcification was observed as reported by McLean and McCoy, using the same method. Calcification in the epiphyseal cartilage was seen at four hours, in the osteoid of the metaphysis at six hours, and in the callus osteoid at eight hours.

III. CONTROL OF CALCIFICATION BY CONTINUED ADMINISTRATION OF PHOSPHATE

In the first series of experiments to be reported in this section, daily injections of phosphate were begun either before or at the time of fracturing, or on the fourth day following the fracture, and continued for several days. As the state of the rachitic epiphyseal cartilage and of the rachitic metaphysis was almost identical in all of the animals, and as the response to the administration of phosphate was uniform this response may be described first.

Within twenty-four hours after the injection, calcification was initiated in the epiphyseal cartilage, in the form of the "line test", as described above. Within forty-eight hours, and following two injections of phosphate, calcification was usually observed in the osteoid zone in the metaphysis, and in the osteoid borders on the old trabeculae of spongy bone at the junction of the rachitic metaphysis with the shaft. With further doses deposition of bone salt continued from both directions toward the central portion of the metaphysis, mainly chondro-osteoid, leaving this portion as the last site to be calcified or removed in the process of regeneration of the spongiosa (Figs. 7, 8, 9, 10, 11, and 12).

Shortly after calcification begins in the cartilage, orderly penetration and removal of cartilage by advancing capillaries begins. These phenomena constitute the beginning of *healing* of rickets, which follows and depends upon calcification, but which is recognizable as distinct from the calcification process itself. A definite time interval elapses between calcification and the cellular evidences of healing, so that calcification may be observed without healing, but as will be reported elsewhere, we have never observed the cellular evidences of healing without calcification.

Injections of Phosphate from the Fourth to Ninth Day and from the Fourth to Twelfth Day Following Fractures

As described above, calcification in the subperiosteal and subendosteal callus osteoid was initiated within twenty-four hours after a single dose of phosphate. Daily injections were continued and the animals were sacrificed at daily intervals to the ninth day. The deposits of bone salt showed a gradual increase in density and in area of distribution (Figs. 10, 11, and 12). After the second injection, many of the dispersed de-

purpose was a mixture of 80 per cent. of one-tenth molar secondary sodium phosphate (M/10 Na_2HPO_4) and 20 per cent. of primary sodium phosphate (M/10 NaH_2PO_4), of which the hydrogen-ion concentration at 38 degrees centigrade corresponded approximately to pH 7.35. The standard dosage employed was 2.5 cubic centimeters (containing approximately 7.5 milligrams of phosphorus) per 100 grams of rat weight. This dose is subtoxic for rachitic rats, rarely resulting in the death of an animal in tetany. Increasing the dosage did not shorten the time required for initiation of calcification in such animals as survived the larger dose (Group R, Table II).

Calcification

As previously shown [14] administration of the standard dose of phosphate results in a zone of calcification in the matrix of the epiphyseal cartilage, typical of the "line test", within twenty-four hours or less. In animals examined from twenty-four to forty-eight hours after administration of phosphate and from five to six days following a fracture there was also beginning calcification in the callus, limited to the subperiosteal and subendosteal osteoid. In preparations fixed with neutral formalin and stained with silver nitrate, the initial deposit was seen as widely dispersed rosette-shaped crystals (Fig. 25). In preparations frozen and dried by the Altmann-Gersh method [8], the deposit was in the form of fine non-crystalline granules (Fig. 24). The distribution of the deposits in the callus was the same after each method of fixation.

Silver staining of the early deposit of bone salt cannot be said to demonstrate the exact stage of aggregation of the salt, but undoubtedly it does demonstrate the density and distribution of this mineral. We have compared the localization of the bone salt, as demonstrated by the silver method described, with that shown by *intra vitam* staining by sodium alizarin sulfonate, by observation of unstained sections with the aid of polarized light, and with the fluorescence seen in calcified areas in ultraviolet light. In all cases the distribution of the bone salt was seen to be identical.

Initiation of Calcification at Various Stages of Healing

Table I illustrates the results of a series of experiments designed to investigate the relative receptivity, at various stages of fracture healing and at various intervals during the period on deficient diet, of the growing osteoid and cartilage to bone salt, in both the rachitic metaphysis and the callus. The rats were given a single injection of phosphate as described above and were killed at intervals up to twenty-four hours following the administration of the phosphate.

Table I shows that after the callus had developed a calcifiable matrix, at three to four days following a fracture (Figs. 7, 8, and 9), the initial deposit of bone salt was seen in the subperiosteal osteoid some four to eight hours later than in the epiphyseal cartilage (Fig. 26). After ten

FIG. 24

Photomicrograph (× 850) shows initial calcification in the callus osteoid following the administration of the phosphate mixture. The specimen was frozen-dried, undecalcified, impregnated with 40-per cent. silver nitrate, and exposed to light.

FIG. 25

Photomicrograph (× 800) shows initial calcification in the callus osteoid following the administration of the phosphate mixture. The undecalcified specimen was fixed in neutral formalin.

FIG. 26

Photomicrograph (× 80) shows progressive calcification of the callus osteoid beginning in the area in contact with the periosteum and moving inward ten days after fracture in rachitic rat and forty-eight hours after the first of two daily injections of the phosphate mixture.

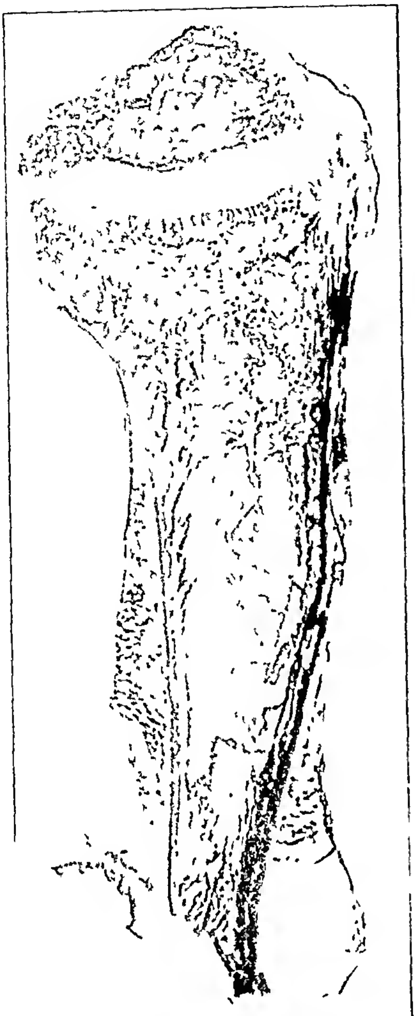


Fig. 21

Photomicrograph (× 8) of longitudinal section through the undecalcified tibia, twelve and one-half days after fracture, of a rachitic rat which had been injected daily with 2.5 cubic centimeters of one-tenth molar of phosphate mixture per 100 grams body weight from the tenth to the twelfth day of healing. There is early calcification and healing in the epiphyseal cartilage, rachitic metaphysis, and callus.

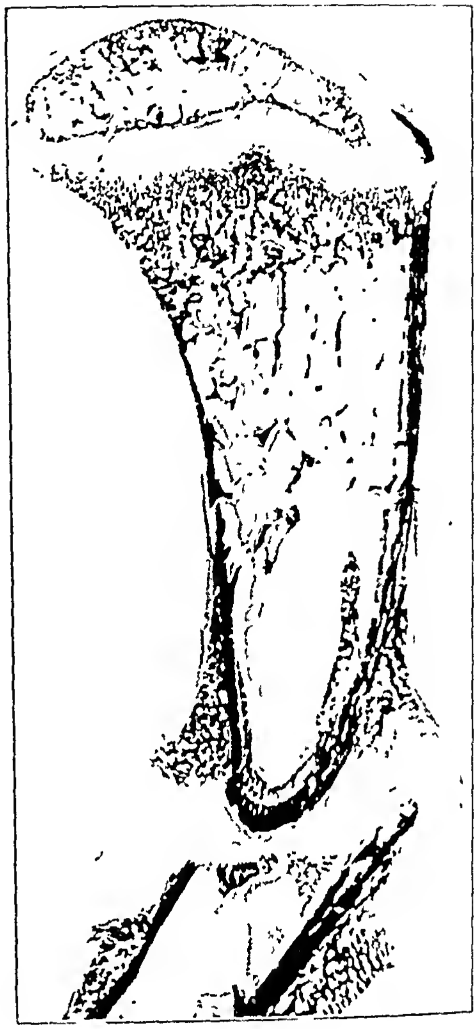


Fig. 22

Photomicrograph (× 8) of longitudinal section through the undecalcified tibia, twelve days after fracture, of a rachitic rat which had been injected daily with 2.5 cubic centimeters of one-tenth molar phosphate mixture per 100 grams of body weight from the fourth to the twelfth day of healing. There is advanced calcification and healing in the epiphyseal cartilage, metaphysis, and callus.

the callus, without a corresponding process in the epiphyseal cartilage or rachitic metaphysis. In order to distinguish this calcification from that induced by the various procedures to be described later we have designated it as *spontaneous calcification.*

Spontaneous calcification appears first in the subperiosteal and subendosteal osteoid at the tenth to the fifteenth day following the fracture. It continues thereafter at a very slow rate. In the hypertrophic cartilage of the callus the time of appearance has been less regular, usually occurring

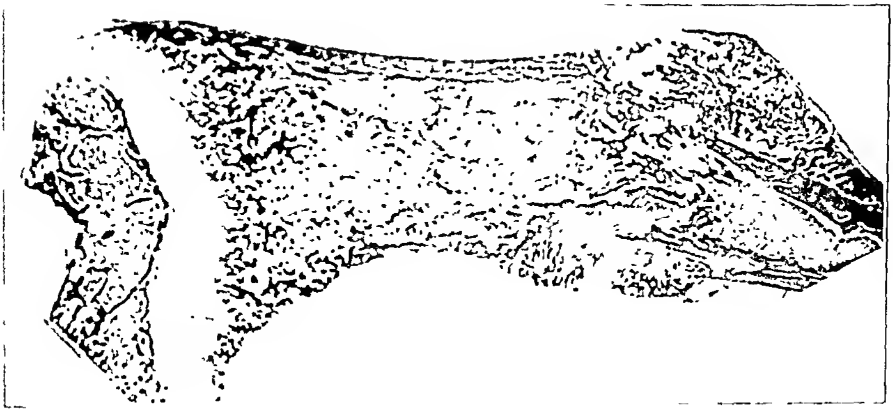


FIG. 23

Photomicrograph (× 8) of longitudinal section through the undecalcified tibia, twenty-two and one-half days after fracture, of a rachitic rat which was injected daily with 2.5 cubic centimeters of one-tenth molar of phosphate mixture per 100 grams of body weight from the fifteenth to the twenty-first day. There is heavy calcification and beginning of union in the fracture callus. Interruption of the healing of rickets is revealed by failure of calcification and resumption of the rachitic type of cartilage removal in the epiphyseal cartilage.

from about the twentieth to the twenty-fifth day, by which time the subperiosteal callus shows a widely distributed deposit. As in the case of induced calcification, described in the following pages, progress of calcification into the callus cartilage is delayed by the encapsulation of the callus cartilage by dense connective tissue and fibrocartilage.

The mechanism of this spontaneous calcification will be considered further in a later paper. This form of calcification is not capable of converting the callus osteoid into fully calcified bone (Figs. 4, 5, and 6). The amount of bone salt deposited is so slight, and the process is so gradual, that, in ordinary roentgenograms, as shown in the illustrations of the papers of Ham, Tisdall, and Drake; and of Compere, Hamilton, and Dewar there is no evidence of calcification throughout the first twenty-five days of healing. In time the callus diminishes in size, is reorganized, and usually, about ten to twenty days after union of the fracture would occur in normal animals, the density of the calcium salts increases sufficiently to become radio-opaque.

II. INITIATION OF CALCIFICATION IN THE CALLUS BY ADMINISTRATION OF A SINGLE DOSE OF PHOSPHATE

Initiation of calcification in the callus was best demonstrated in rats fifty-four days old, five days after a fracture and twenty-four hours following the administration of a single standard dose of a standard phosphate solution.

Rats, weaned to the rachitogenic diet at the age of twenty-one days and given fractures at the age of forty-nine days, were given phosphate solution intraperitoneally four days after the fracture and were killed twenty-four hours later. The standard phosphate solution used for this

purpose was a mixture of 80 per cent. of one-tenth molar secondary sodium phosphate (M/10 Na_2HPO_4) and 20 per cent. of primary sodium phosphate (M/10 NaH_2PO_4), of which the hydrogen-ion concentration at 38 degrees centigrade corresponded approximately to pH 7.35. The standard dosage employed was 2.5 cubic centimeters (containing approximately 7.5 milligrams of phosphorus) per 100 grams of rat weight. This dose is subtoxic for rachitic rats, rarely resulting in the death of an animal in tetany. Increasing the dosage did not shorten the time required for initiation of calcification in such animals as survived the larger dose (Group R, Table II).

Calcification

As previously shown [14] administration of the standard dose of phosphate results in a zone of calcification in the matrix of the epiphyseal cartilage, typical of the "line test", within twenty-four hours or less. In animals examined from twenty-four to forty-eight hours after administration of phosphate and from five to six days following a fracture there was also beginning calcification in the callus, limited to the subperiosteal and subendosteal osteoid. In preparations fixed with neutral formalin and stained with silver nitrate, the initial deposit was seen as widely dispersed rosette-shaped crystals (Fig. 25). In preparations frozen and dried by the Altmann-Gersh method [8], the deposit was in the form of fine non-crystalline granules (Fig. 24). The distribution of the deposits in the callus was the same after each method of fixation.

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Initiation of Calcification at Various Stages of Healing

Table I illustrates the results of a series of experiments designed to investigate the relative receptivity, at various stages of fracture healing and at various intervals during the period on deficient diet, of the growing osteoid and cartilage to bone salt, in both the rachitic metaphysis and the callus. The rats were given a single injection of phosphate as described above and were killed at intervals up to twenty-four hours following the administration of the phosphate.

Table I shows that after the callus had developed a calcifiable matrix, at three to four days following a fracture (Figs. 7, 8, and 9), the initial deposit of bone salt was seen in the subperiosteal osteoid some four to eight hours later than in the epiphyseal cartilage (Fig. 26). After ten

FIG. 24

Photomicrograph (× 850) shows initial calcification in the callus osteoid following the administration of the phosphate mixture. The specimen was frozen-dried, undecalcified, impregnated with 40-per cent. silver nitrate, and exposed to light.

FIG. 25

Photomicrograph (× 800) shows initial calcification in the callus osteoid following the administration of the phosphate mixture. The undecalcified specimen was fixed in neutral formalin.

FIG. 26

Photomicrograph (× 80) shows progressive calcification of the callus osteoid beginning in the area in contact with the periosteum and moving inward ten days after fracture in rachitic rat and forty-eight hours after the first of two daily injections of the phosphate mixture.

TABLE I

Initiation of Calcification in the Epiphyseal Cartilage, Metaphysis, Callus Osteoid, and Callus Cartilage in Rachitic Rats, Following Intraperitoneal Administration of a Single Dose of M/10 Phosphate Mixture, 2.5 Cubic Centimeters (7.5 Milligrams Phosphorus) per 100 Grams of Body Weight

Group	Number of Days of Healing	Total Number of Days on Diet	Number of Hours after Injection	New Calcification			
				Epiphyseal Cartilage	Metaphysis	Callus Osteoid	Callus Cartilage
A	0	28	0	–	–		
	0		8	–	–		
	0		24	+	–		
	0		24	+	–		
B	3	31	0	–	–	–	–
	3		4	–	–	–	–
	3		8	–	–	–	–
	3		12	+	–	–	–
	3		24	+	+	+	–
C	4	32	0	–	–	–	–
	4		4	–	–	–	–
	4		8	–	–	–	–
	4		10	–	–	–	–
	4		12	–	–	–	–
	4		14	+	–	–	–
	4		24	+	+	+	–
D	5	33	0	–	–	–	–
	5		1	–	–	–	–
	5		2	–	–	–	–
	5		3	–	–	–	–
	5		4	+	–	–	–
	5		5	+	–	–	–
	5		6	+	+	–	–
	5		8	+	+	+	–
E	7	35	0	–	–	–	–
	7		14	–	–	–	–
	7		24	+	±	+	–
F	8	36	0	–	–	–	–
	8		0	–	–	–	–
	8		0	–	–	–	–
	8		24	+	±	+	–
G	10	38	0	–	–	+	–
	10		0	–	–	+	–
	10		0	–	–	+	–
	10		4	–	–	+	–
	10		12	–	–	+	–
	10		24	–	–	+	–
	12	40	4	–	–	+	–
	12		8	–	–	+	–
	12		24	–	–	+	–
H	12	41	0	–	–	+	–
	15	43	0	–	–	++	–
	15		0	–	–	++	–
I	16	44	0	–	–	++	–
	20	48	0	–	–	++	±
	26	54	0	–	–	+++	+
	28	56	0	–	–	+++	++

days following a fracture and thirty-eight days on the rachitogenic diet it was more difficult to initiate calcification in the epiphyseal cartilage (Fig. 27). Later, frequently after fifteen days, there appeared spontaneous calcification in the callus osteoid. The density of the deposit in the callus

osteoid increased up to twenty-eight days following the fracture, and in animals examined twenty-six and twenty-eight days after a fracture there was also spontaneous calcification in the matrix of the callus cartilage.

In one litter of rats (Group D, Table I) the bones were studied by means of unfixed, hand-cut, quick-stained (10-per-cent. silver nitrate) sections. In these preparations calcification was observed as reported by McLean and McCoy, using the same method. Calcification in the epiphyseal cartilage was seen at four hours, in the osteoid of the metaphysis at six hours, and in the callus osteoid at eight hours.

III. CONTROL OF CALCIFICATION BY CONTINUED ADMINISTRATION OF PHOSPHATE

In the first series of experiments to be reported in this section, daily injections of phosphate were begun either before or at the time of fracturing, or on the fourth day following the fracture, and continued for several days. As the state of the rachitic epiphyseal cartilage and of the rachitic metaphysis was almost identical in all of the animals, and as the response to the administration of phosphate was uniform this response may be described first.

Within twenty-four hours after the injection, calcification was initiated in the epiphyseal cartilage, in the form of the "line test", as described above. Within forty-eight hours, and following two injections of phosphate, calcification was usually observed in the osteoid zone in the metaphysis, and in the osteoid borders on the old trabeculae of spongy bone at the junction of the rachitic metaphysis with the shaft. With further doses deposition of bone salt continued from both directions toward the central portion of the metaphysis, mainly chondro-osteoid, leaving this portion as the last site to be calcified or removed in the process of regeneration of the spongiosa (Figs. 7, 8, 9, 10, 11, and 12).

Shortly after calcification begins in the cartilage, orderly penetration and removal of cartilage by advancing capillaries begins. These phenomena constitute the beginning of *healing* of rickets, which follows and depends upon calcification, but which is recognizable as distinct from the calcification process itself. A definite time interval elapses between calcification and the cellular evidences of healing, so that calcification may be observed without healing, but as will be reported elsewhere, we have never observed the cellular evidences of healing without calcification.

Injections of Phosphate from the Fourth to Ninth Day and from the Fourth to Twelfth Day Following Fractures

As described above, calcification in the subperiosteal and subendosteal callus osteoid was initiated within twenty-four hours after a single dose of phosphate. Daily injections were continued and the animals were sacrificed at daily intervals to the ninth day. The deposits of bone salt showed a gradual increase in density and in area of distribution (Figs. 10, 11, and 12). After the second injection, many of the dispersed de-

posits became denser and new patches of beginning calcification appeared. Additional bone salt laid down after the third injection converted many of the deposits into denser masses, which, after the fourth (Fig. 28) and

FIG. 27

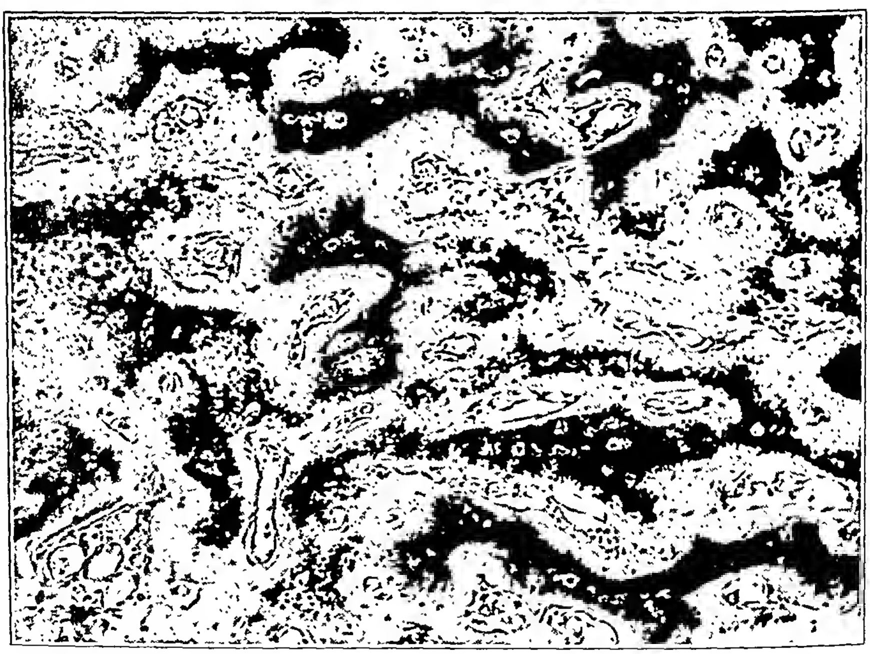

FIG. 28

Photomicrographs (× 140) show progress of calcification in the subperiosteal osteoid, following fractures in rachitic rats. Fig. 27: in untreated rachitic rat eight days after fracture the osteoid is completely devoid of bone salt; Fig. 28: shows calcification of cores of trabeculae after four daily injections of phosphate mixture, with the total phosphorus injected being thirty milligrams

fifth injections were found fusing with other closely adjacent deposits until the cores of many of the trabeculae were uniformly and densely calcified. The densest deposits of the bone salt, as seen in frozen-dried as

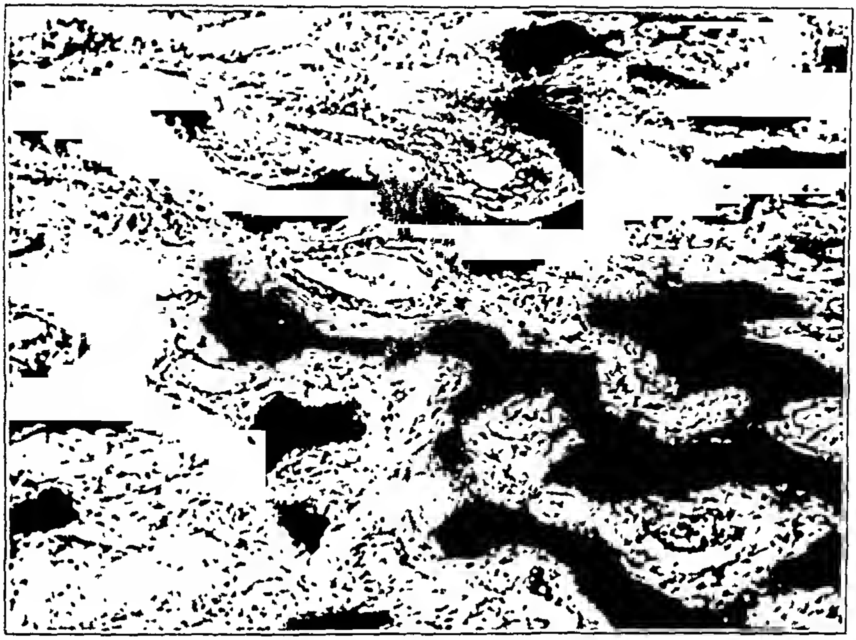

FIG. 29

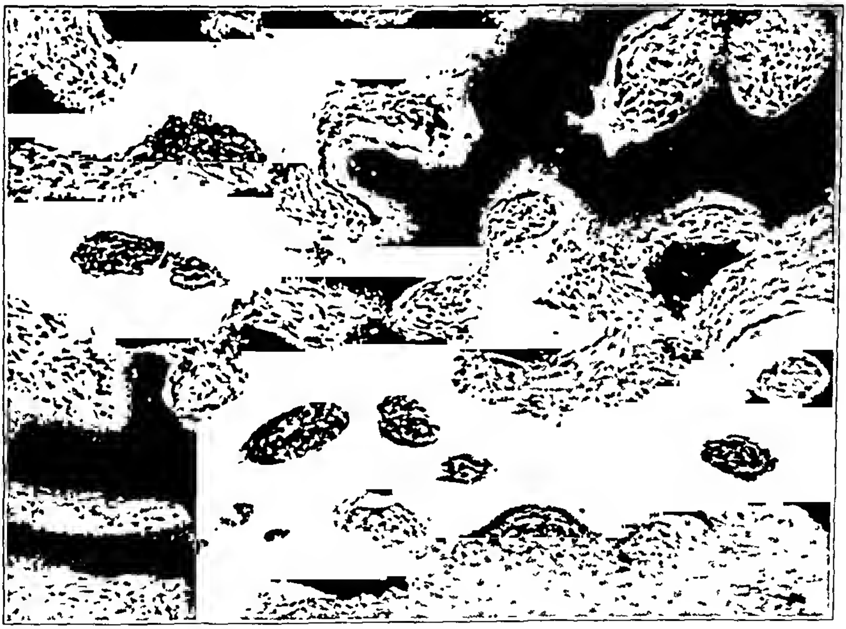

FIG. 30

per 100 grams of body weight; Fig. 29: increased density of calcification with 105 milligrams of phosphorus, as phosphate, injected in sixty hours; and Fig. 30: almost complete calcification, with thin osteoid sheaths, with 135 milligrams of phosphorus, as phosphate, injected in ninety hours.

well as in formalin-fixed tissues, were usually, but not always, in the cores of the trabeculae.

As in previously normal animals, calcification of the matrix of the callus cartilage occurs only when hypertrophic cartilage is in contact with the periosteum, or with advancing subperiosteal and subendosteal bone. In the animals in this series, in which injections of phosphate were begun on the fourth day following a fracture, the callus cartilage had become, in large part, embedded or encapsulated in dense fibrous tissue and fibrocartilage, as described in Section I. This constituted a barrier to the advance of the new intramembranous bone, so that it was not until the ninth day following the injury, or the fifth day of administration of phosphate, that contact of calcifying new bone with hypertrophic cartilage was accomplished. At this stage calcification was observed to begin in the cartilage matrix, but was limited, as in the normal animal, to the periphery of the callus cartilage where contact with new bone was established, the great mass of callus cartilage remaining uncalcified. At this time, also, there was no resumption of the removal and replacement of cartilage.

In another litter in which phosphate was given similarly until the twelfth day, it was observed that calcification in the subperiosteal intramembranous bone was greatly increased in density (Figs. 12 and 22), and that there were several areas of calcified hypertrophic cartilage in contact with the cambium layer of the periosteum. As to the penetration of the central fibrocartilaginous callus by osteogenic tissue, and as to the replacement of cartilage by bone, the animals which received phosphate from the ninth to the twelfth days of fracture healing showed little advance over those which received phosphate only to the ninth day. The newly calcified cartilage in contact with periosteum was penetrated by mesenchyme over a wide front with the formation of primary spongiosa, but there was as yet slight evidence of bone formation. Fibrous connective tissue, fibrocartilage, and chondro-osteoid separated the central callus from the areas of bone formation around the shaft, and, although these tissues were not yet being ossified, penetration by blood vessels and mesenchyme, and resorption of fibrocartilage and chondro-osteoid were under way.

Daily Injections of Phosphate from the Eighth to the Twenty-Fourth Day

As described in the foregoing sections, the callus, after four days, was so organized as to show separation of the subperiosteal and subendosteal osteoid from the central cartilaginous callus. At eight days, the fibrous connective tissue and fibrocartilage, which constituted the separating capsule, became more dense and highly developed than that seen in earlier stages. When phosphate was injected and calcification was initiated at nine days (Figs. 13, 14, 15, and 26) and continued even to fourteen or fifteen days, the bone salts were deposited almost exclusively in the subperiosteal and subendosteal osteoid, and only in such hypertrophic car-

tilage as was in direct contact with the periosteum. Limited to these areas, the deposits become very dense and widely distributed in the osteoid. Only after seven to eight days of phosphate administration (sixty milligrams of phosphorus) was there evidence of appreciable invasion and resorption, with calcification and ossification of the fibrocartilaginous callus. Continuing phosphate from the sixteenth to the twenty-fourth day of healing, when union occurred in the normal littermate, there was so much chondro-osteoid, fibrocartilage, and fibrous connective tissue to be resorbed that calcification, replacement, and ossification of the cartilage proceeded very irregularly and apparently followed the lines of least resistance to the invasion of mesenchyme. Though union finally occurred at twenty-four days, considerably in advance of untreated littermates, the structure of the new bone across the fracture line was defective. Ossifying fibrocartilage, fragments of calcified cartilage incorporated in bone trabeculae, and partially calcified osteoid were distributed in disorganized fashion between the fracture ends.

Daily Injections Begun at the Time of Fracture, or Two Days before Fracturing, Respectively

The initial stages of repair of the fracture showed no differences from those described as common to normal and rachitic animals. Between the fourth and fifth days following the injury, however, the picture differed from that just described and from that in florid rickets, in that partially calcified osteoid and calcified cartilage matrix were in communication. Encapsulation of the callus cartilage had not occurred, and there was no barrier to or lag in the invasion of the fibrocartilaginous callus by the osseous tissue arising from the periosteum. Except for deficient calcification in the newly formed osseous tissue, the process and the time relationships were essentially those seen in the normal animal.

Interruption of Calcification and Healing, and Its Prevention

In animals treated with daily injections of one-tenth molar phosphate solution there was seen not infrequently an interruption of calcification and resumption of the rachitic type of cartilage removal (Fig. 23). The following experiment was designed to study this phenomenon, and to observe the progress of calcification under conditions which assured the maximum supply of available phosphate continuously.

A litter of rachitic rats were given fractures after thirty days on the rachitogenic diet. Three days later injections of standard doses of one-tenth molar phosphate were given; half of the animals received one dose only, the remaining animals received a similar dose twenty-four hours later. The animals were sacrificed at twelve-hour intervals after the last injection.

There was found regularly at thirty-six hours, and occasionally at twenty-four hours, after the final injection a zone of calcified cartilage four to six cells wide in the rachitic metaphysis, separated from the un-

TABLE II

THE PROGRESS OF CALCIFICATION IN THE EPIPHYSEAL CARTILAGE, METAPHYSIS, CALLUS OSTEOID, AND CALLUS CARTILAGE IN RACHITIC RATS, FOLLOWING FORCED INTRAPERITONEAL ADMINISTRATION OF PHOSPHATES

Group	Number of Days of Healing	Total Phosphorus Injected, Mgs. per 100 Gm. of Rat Weight	Number of Hours from First Dose	Rate of Injection of M/10 Phosphate per 100 Gm. of Rat Weight	New Calcification			
					Epiphyseal Cartilage	Metaphysis	Callus Osteoid	Callus Cartilage
P	4 8	0	–	–	–	–	–	–
	4 1	9	3	1 c.c. per hr.	–	–	–	–
	4 2	18	6	1 c.c. per hr.	–	–	–	–
	4 4	30	10	1 c.c. per hr.	+	–	–	–
	4 7	54	18	1 c.c. per hr.	+	+	+	–
Q	12 7	0	–	–	–	–	+	–
	10 2	75	30	1 c.c. per hr. for 20 hrs.; 1 c.c. per 2 hrs. for 10 hrs.	++	+	+	–
	11 5	105	60	1 c.c. per hr. for 20 hrs.; 1 c.c. per 2 hrs. for 10 hrs.; 1 c.c. per 3 hrs. for 30 hrs.	++	++	++	+
	12 7	135	90	1 c.c. per hr. for 20 hrs.; 1 c.c. per 2 hrs. for 10 hrs.; 1 c.c. per 3 hrs. for 60 hrs.	++++	++++	++++	++++
R	8 0	0	–	–	–	–	–	–
	7 1	22.5	3	1 dose only	–	–	–	–
	7 5	22.5	12	1 dose only	–	–	–	–
	8 0	22.5	24	1 dose only	++	+	+	±

calcified epiphyseal cartilage by a narrow plate of fibrous tissue rich in blood vessels. This is the typical picture of interruption of the process of calcification and healing, and indicates that a twenty-four-hour period between doses of phosphate is barely sufficient, in the majority of instances, to keep these processes progressing continuously.

The callus of healing fractures in the same bones showed corresponding effects upon the distribution of bone salts deposited in the subperiosteal osteoid. The bone salt was found in the osteoid closest to the periosteum at twelve and at twenty-four hours after the last injection of phosphate in animals receiving either one or two injections. At thirty-six or more hours after the injection a wide layer of uncalcified osteoid was found between the periosteum and the newly calcified bone. The callus cartilage was uncalcified throughout the series.

Forced Administration of Phosphate at Maximum Possible Rate

In this experiment the progress of calcification was observed under conditions which maintained the supply of phosphate to the animal at the

greatest possible rate. Two litters of rachitic, fractured rats were injected repeatedly, each with one cubic centimeter of one-tenth molar phosphate solution per 100 grams of rat weight (three milligrams of phosphorus per 100 grams rat weight). The injections were given hourly until the occurrence of fibrillary muscular twitching, loss of posture, or convulsions, at which time, usually the twentieth hour, one cubic centimeter of one-tenth molar calcium chloride (M/10 $CaCl_2$) was given subcutaneously. The animals which survived were given additional injections of phosphate at two-hour intervals. About ten hours later the animals again went into tetany; calcium chloride was given as before, and the phosphate injections were continued at three-hour intervals. Thereafter it was possible to continue to sixty hours (from beginning the injections) without a serious number of casualties. The rats were at all times in contact with the high-calcium rachitogenic diet, which was consumed avidly. The schedule of fracture healing, and times at which the injections were given and the bones were observed is shown in Table II.

No marked differences between these animals and those given standard doses of phosphate at intervals of twenty-four hours became manifest until the sixtieth hour following the first injection. At this time there was almost continuous union between the calcified cartilage and the spongy bone in both the callus (Figs. 32 and 33) and the metaphysis. New bone in the process of deposition was calcified as rapidly as it was laid down and the osteoid everywhere in the bone and in the callus showed a heavy, uniformly distributed, though incomplete, impregnation of bone salt (Fig. 29). Transforming fibrocartilage and much of the osteoid, containing cartilage cells, was uncalcified.

At ninety hours, at which time the rats had received 135 milligrams of phosphorus per 100 grams of body weight, there was advanced calcification and healing in the epiphyseal cartilage and metaphysis (Figs. 16, 17, and 18). Dense calcification was observed in the osteoid everywhere in the original bone and in the callus (Fig. 30). Callus cartilage was as well calcified as in the normal animal at the same stage of fracture healing (Fig. 34), and the junctions between calcified cartilage and bone were continuous in both the metaphysis and in the callus. Certain areas of the chondro-osteoid contained calcium salts, but much of this tissue remained unimpregnated while undergoing resorption associated with the formation of osteoclasts. Fibrocartilage and areas of cartilage in the process of replacement by bone were calcified wherever contact was made with osteogenic tissue, but most of these tissues showed no bone salt in the intercellular substance.

IV. CALCIFICATION FOLLOWING ADMINISTRATION OF VITAMIN D

Observations were made upon the influence of vitamin D, in small and in large doses, in comparison with the effects of phosphate in inducing calcification in the epiphyseal cartilage, the metaphysis, and the fracture callus in rachitic rats.

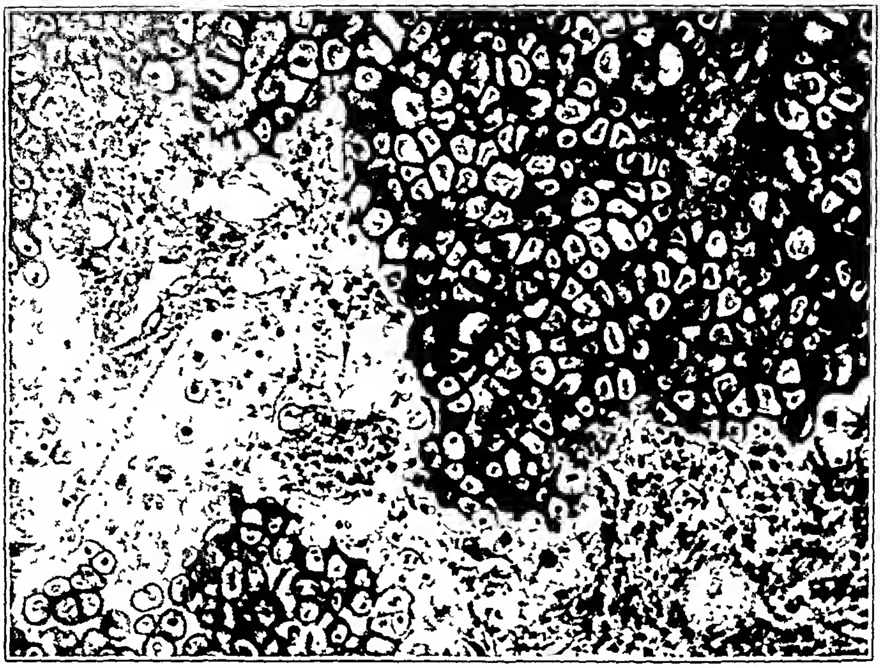

Fig. 31

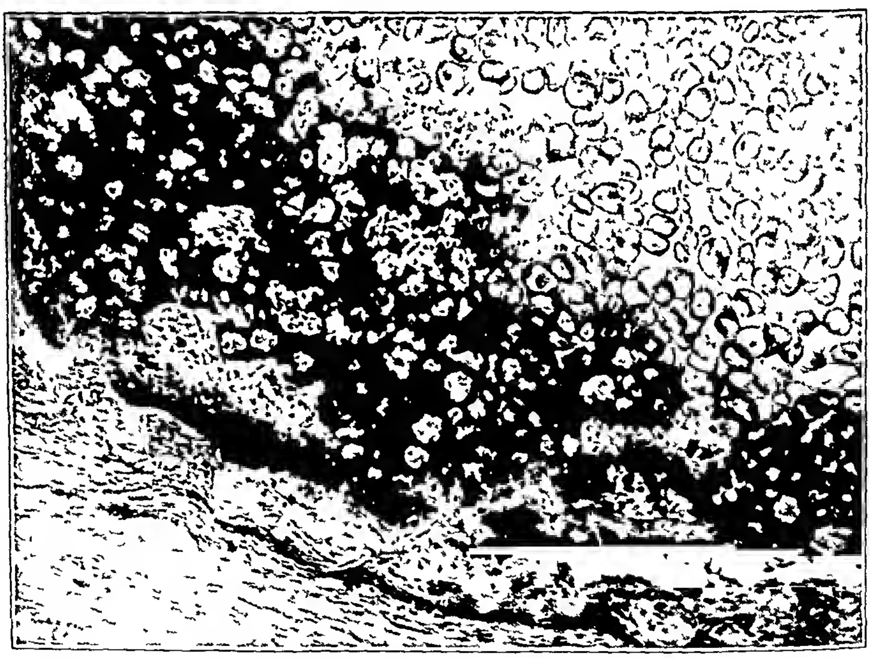

Fig. 32

Photomicrographs (× 140) show progress of calcification in the callus cartilage, following fractures in rachitic rats. Fig. 31: Shows, fifteen days after a fracture in a rachitic rat, completely uncalcified cartilage with invasion and the rachitic type of cartilage removal. Fig. 32: Subperiosteal intracartilaginous ossification twelve days following fracture in a rachitic rat which had been injected with 105 milligrams of phosphorus, as phosphate, in sixty hours. The process simulates periosteal collar and formation of ossification center in

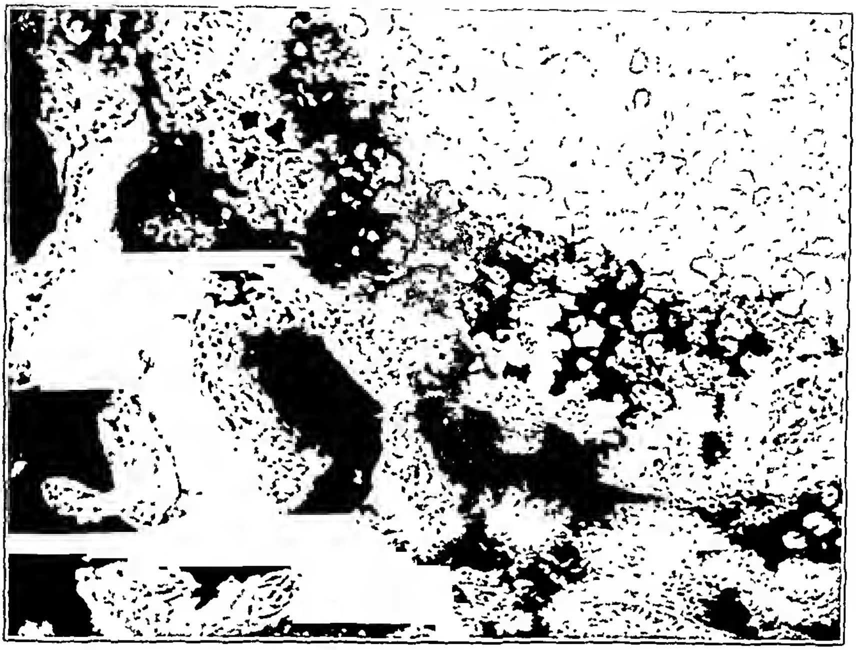

Fig. 33

Fig. 34

embryonic bone (Bloom and Bloom). Fig. 33: Taken from the same rat as Fig. 32, at the junction of the calcified cartilage matrix and the calcified subperiosteal osteoid. It suggests primary spongiosa (compare with Fig. 10, Urist and McLean [20]). Fig. 34: Final stages of intracartilaginous ossification thirteen days after fracture in a rachitic rat which was injected with 135 milligrams of phosphorus, as phosphate, in ninety hours.

Calcification in Animals Maintained on a Vitamin-Fortified, Phosphate-Deficient Diet

It is well known that if small quantities of vitamin D are added to the Steenbock-Black diet, rickets does not appear [1,11], but bones which have a lower ash content and are smaller and thinner than normal are produced [18]. Experiments modeled after those of Shohl were undertaken with the view of learning whether the dietary conditions of reduction in phosphate intake, plus a supplement of vitamin D, would demonstrate calcification proceeding in the callus at a uniform minimum rate.

Two litters of twenty-one-day-old rats were divided into three groups to be weaned as: normal controls on the Bills diet; rachitic controls on the Steenbock-Black diet; experimental animals on the Steenbock-Black diet to which 2-per-cent. cod-liver oil had been added. The right tibiae of all were fractured at forty-nine days, and the experimental animals were divided into two groups, one of which received daily injections of 2.5 cubic centimeters of one-tenth molar phosphate per 100 grams of body weight. The normal and rachitic control groups showed normal states of calcification, on the one hand, and typical rachitic failure of calcification on the other.

The experimental groups, which were maintained on the same rachitogenic diet plus a small quantity of vitamin D, showed that the rate of calcification in growing bone and cartilage was not normal (Fig. 19). The epiphyseal cartilage was wider than normal, and the zone of provisional calcification was reduced in width. There was no chondro-osteoid in the metaphysis. The shaft was rarefied, and exhibited a considerable amount of osteoid. There was osteoid in the callus, especially at the junction between the cartilage and the advancing osseous tissue.

Calcification in the Callus in Rachitic Animals Given Large Doses of Viosterol

Two litters of rachitic rats with one-to-four-day and four-to-eight-day-old fractures were given doses of 10,000 international units of viosterol daily, by stomach tube. Two similar litters with four-to-ten-day-old fractures were given 500,000 international units daily. The bones were examined from the second to the eighth and from the fifth to the tenth day following the fractures. The animals were at all times kept on the Steenbock-Black rachitogenic diet.

Group Given 10,000 International Units of Viosterol Daily. The course and distribution of the deposition of mineral in the metaphysis and in the callus of the rachitic rats given 10,000 international units of viosterol daily were almost exactly the same as those following the administration of phosphate. The bone salt appeared in the epiphyseal cartilage and in the callus osteoid within forty-eight hours after the first dose, and increased rapidly in density and in distribution thereafter. The most striking difference seen was that after the administration of viosterol,

resorption of the chondro-osteoid of the metaphysis was much more rapid than after the administration of phosphate.

Group Given 500,000 International Units of Viosterol Daily. Viosterol in doses of 500,000 international units daily initiated calcification in the epiphyseal cartilage and in the osteoid at about the same time as did smaller doses of viosterol, or the administration of phosphate. The larger doses of viosterol, however, considerably modified the healing process in the rachitic metaphysis, and the reparative processes in the fracture callus. After three to four daily doses, the partially calcified osteoid tissue in the metaphysis, the shaft, and the callus, and the compact bone of the shaft showed widespread resorption associated with the presence of large numbers of osteoclasts. By the fourth or fifth day after administration of viosterol was begun, there was also a widespread beginning formation of new bone, associated with many osteoblasts, in the areas of resorption including the fracture callus.

V. THE RELATIONSHIP BETWEEN THE STATE OF THE BODY MINERAL STORES AND THE PROGRESS OF CALCIFICATION IN THE CALLUS OF HEALING FRACTURES

All of the above experiments were on young growing animals. The experiment here reported was undertaken to determine whether the healing of a fracture in an adult animal, with abundant stores of bone mineral, would be affected by a diet deficient in phosphorus and in vitamin D.

Twelve adult rats, which had been maintained on a stock diet for eighteen or more months, were transferred to the Steenbock-Black rachitogenic diet for a period of ten weeks. The right tibiae were then fractured and the animals were sacrificed at three-day intervals.

In all of the animals studied the spongiosa and some parts of the shaft showed very thin osteoid borders upon the bone trabeculae. Bone and the matrix of hypertrophic cartilage were densely calcified in all parts of the callus, and, except for a narrow zone of osteoid between the cartilage and the bone in the callus, there was no evidence of a mineral deficiency in the early stages of healing. The fractures united at approximately the same time as those of the controls.

DISCUSSION

As stated in the introduction to this paper, the object of these experiments was not so much to study the healing of fractures in rickets as it was to make the process of calcification and its relationship to the repair of bone accessible to analysis. For this reason the discussion will be limited to these aspects of the subject; the other essential findings reported in the paper will be included in the summary and conclusions.

In the condition of florid rickets, resulting from phosphorus deficiency, the fracture callus in rats remains completely devoid of bone salt for a period of ten to fifteen days. During this period the influence of the absence of calcification upon the healing of fractures, and the effects of

the initiation of calcification can be observed directly. At about the end of this period, calcification of the callus begins spontaneously, without simultaneous calcification in the epiphyseal cartilage and the rachitic metaphysis. Analysis of this phenomenon is a separate problem, and will be reported upon in another paper.

For the purpose of inducing calcification we have employed chiefly intraperitoneal administration of the orthophosphates of sodium, in a mixture at a hydrogen-ion concentration corresponding to pH 7.35, for the reason that the dosage supplied in this form may be accurately gauged. For purposes of comparison we have also induced calcification by the administration of viosterol, and have shown that calcification so induced does not differ from that induced by administration of phosphate.

From this and the preceding paper [20] the fact stands out that, given an adequate supply of bone minerals, calcification of the matrix of hypertrophic cartilage and of osseous tissue occurs promptly and decisively. These tissues must be regarded as already prepared for calcification, the presence or absence of bone salt depending upon the available supply of minerals.

Of especial interest is the influence of calcification, or of its absence, upon the healing process in the callus. As pointed out above, osteogenesis and calcification cannot be separated in the normal animal, so that it is impossible, from the study of normal animals alone, to determine how much the healing process itself is influenced by the deposition of bone salt in the matrix of cartilage and bone. These interrelationships have, however, been clearly demonstrated in the experiments and observations reported in this paper.

As described above, the healing process in the fractures produced in rachitic rats begins in the same way as in normal rats, and the formation of the fibrocartilaginous cartilage and the production of subperiosteal and subendosteal osseous tissue proceed just as in the normal animal, but in the absence of calcification. Evidently, then, calcification is not essential to the early stages of the healing of fractures, including the beginning of osteogenesis.

Up to the fourth or fifth day following the injury, the new tissues formed in the rachitic rat are indistinguishable from those formed in the normal rat subjected to the same procedure. But at about this time a difference appears, clearly dependent upon the absence of calcification. In the normal rat, at this time, the new intramembranous bone has gained contact with the fibrocartilaginous callus, and removal of the latter with its replacement by bone is well under way. In the rachitic rat there is a definite lag in the invasion of the callus cartilage by osseous tissue, so that active removal and replacement of the cartilage does not begin until about the ninth to the twelfth day following the fracture. In the meantime the cartilage of the callus has often become encased or encapsulated in dense connective tissues and fibrocartilage (Fig. 20).

When removal of the callus cartilage does begin, it is of the rachitic

type, duplicating almost exactly the process in the rachitic metaphysis. But the encapsulation of the callus cartilage forms a partial barrier to the process of cartilage removal, and invasion of the fibrous tissue of the callus proceeds slowly and with considerable delay.

It is difficult to determine to what extent these difficulties might be overcome in the complete absence of calcification, for the reason that in our experiments spontaneous calcification always occurred in the callus, thereby altering the picture. But it is of great interest that just as there is a lag in the healing process in the absence of calcification, so is there a lag in the response to calcification, whether spontaneous or induced.

As shown above, if calcification is induced in rachitic animals prior to the fourth or fifth day following a fracture, or before the changes characteristic of the absence of calcification have appeared, healing of the fracture proceeds in the same way and with the same rapidity as in the previously normal animal. If, however, initiation of calcification is delayed until the callus cartilage has been "encapsulated", or until the fourth to tenth days, there may be a further delay of several days until the barrier of the capsule can be overcome, and the normal type of removal and replacement of the cartilage can begin.

From the above there emerges the general principle that the initiation of healing of experimental fractures in the rat is not materially affected by dietary factors which prevent calcification, but that in the absence of calcification the healing process is both retarded and transformed into a rachitic type of response. Moreover, when conditions for calcification are restored, there is a delay in restoration of the normal healing processes, owing to encapsulation of the callus cartilage in a dense mass of connective tissue. Thus, even a temporary failure of calcification may materially retard the subsequent union of fractures. Studies of human material are now under way, in order to determine whether a similar process may be responsible for delayed union or non-union in man.

Attention has been called to the rôle of the body mineral stores as a source of calcium salts which may be mobilized under the emergency of a healing fracture. This has been shown in adult animals, whose growth is nearly static and whose bone-mineral stores are nearly maximal, by removing phosphorus from the diet. After a period long enough to present conditions of phosphorus-deficiency without complete failure in the calcification mechanism, it was possible to show that the callus of a healing fracture receives bone mineral elements mobilized from the readily available body stores, and solid union may occur at the normal time with no other source of phosphorus. In an adult rat with a well-developed skeleton, it should not be necessary to supplement the diet with mineral solely for the purpose of *enforcing the structure of the uniting fracture*, but possibly in individuals with multiple fractures and in the very young, in whom the rapidly growing bone tissue everywhere in the body demands a continuous supply of mineral, measures supporting mineral metabolism at its highest level are indicated from the earliest period after a fracture occurs.

SUMMARY AND CONCLUSIONS

1. The early stages of healing of fractures in rachitic rats resemble the same process in the previously normal animal in every respect except that of calcification. Formation of the fibrocartilaginous callus, and the production of subperiosteal and subendosteal intramembranous osseous tissue are not influenced by the complete absence of bone salt, in the first four to five day's following a fracture.

2. The influence of the absence of calcification on the healing of fractures in rachitic rats begins to manifest itself by about the fourth to the fifth day following a fracture. Invasion of the fibrocartilaginous callus by the new intramembranous osseous tissue is delayed, often until the ninth to the twelfth day. This delay is comparable to the delay in initiation of the rachitic type of cartilage removal in the epiphyseal cartilage following the onset of rickets. When invasion of the callus cartilage occurs, it closely resembles the similar process in the epiphyseal cartilage in rickets.

3. Healing of fractures in rachitic rats, in the absence of calcification, may be further complicated by the embedding or encapsulation of the callus cartilage in a dense mass of fibrous tissue or fibrocartilage. This forms a barrier to the advance of the uncalcified osseous tissue.

4. Spontaneous calcification in the intramembranous osseous tissue of the callus without calcification in the epiphyseal cartilage or in the rachitic metaphysis begins in the rat at about the tenth to the fifteenth day following the injury, and leads eventually to union of the fracture by partially calcified osteoid.

5. Calcification in the osteoid of the callus, as well as in the epiphyseal cartilage and in the osteoid of the rachitic metaphysis, may be initiated by a single dose of phosphate, in a dose of 2.5 cubic centimeters of one-tenth molar phosphate mixture per 100 grams of body weight. Following such treatment the initial deposit of bone salt in the subperiosteal osteoid occurs some four to eight hours later than in the epiphyseal cartilage.

6. The distribution of bone salt in the epiphyseal cartilage, metaphysis, and callus following administration of phosphate is the same whether fixation is with neutral formalin or by the Altmann-Gersh freezing-drying method. Its localization is also identical, whether visualized by staining with silver nitrate, by *intra vitam* staining with sodium alizarin sulfonate, by observation of unstained sections with the aid of polarized light, or by the fluorescence seen in calcified areas by ultraviolet light.

7. As in previously normal animals, calcification of the matrix of the callus cartilage, following the administration of phosphate, occurs only when hypertrophic cartilage is in contact with the periosteum, or with advancing subperiosteal or subendosteal bone. When the callus has become encapsulated in the dense fibrous tissue or fibrocartilage, which forms a barrier to the advance of the new osseous tissue, there is a

delay of some days in the initiation of calcification of the callus cartilage following the administration of repeated doses of phosphate. When phosphate is given at the time of the fracture, or earlier, so that no barrier is formed, newly formed but poorly calcified osseous tissue gains contact with the callus cartilage without delay, and cartilage removal proceeds in an essentially normal fashion, with normal time relationships.

8. If phosphate is administered at longer intervals than twenty-four hours there is interruption of calcification, and resumption of the rachitic type of cartilage removal in the epiphyseal cartilage. A twenty-four-hour period between doses is barely sufficient, in the majority of instances, to maintain a continuous process of calcification. When phosphate administration is forced at the maximum possible rate, calcification in the callus is greatly accelerated, but an increased rate of phosphate administration, or an increased initial dose, has no demonstrable effect on the time of appearance of the initial calcification in the epiphyseal cartilage or in the callus.

9. A diet inadequate in phosphate, but with a supplement of two-per-cent. cod-liver oil, does not produce the gross lesions of rickets, or the manifestations of absence of calcification in the fracture callus. The distribution of the bone salt deposited in the bone and in the callus are the same whether large doses of viosterol, or phosphates are administered. Still larger doses of viosterol initiate pathological resorption of bone and of osteoid, and seriously interfere with the healing of fractures.

10. When an adult rat with a previously normal skeleton is transferred to a rachitogenic phosphate-deficient diet, calcification in the callus is adequate to produce bony union at the normal time, and there is only a very slight lag in calcification in the osseous tissue of the callus.

11. It is suggested that the observations upon the retardation of the healing process in the absence of sufficient mineral to produce calcification in the callus, and upon the delay in the initiation of a normal type of response when treatment is initiated, which results from encapsulation of the callus cartilage in a dense mass of connective tissue and fibrocartilage, may have a bearing upon certain problems of delayed union or non-union.

Our thanks are due to I. Gersh, Ph.D., of the Department of Anatomy, Johns Hopkins Medical School, for making possible the experiments upon calcification observed with the aid of frozen-dried fixation, and for assisting the work in other ways. We wish also to acknowledge the aid of A. H. Pfund, Ph.D., of the Department of Physics, Johns Hopkins University, in the preparation of demonstrations of the optical properties of bone tissue in ultraviolet and polarized light.

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CUFF RESECTION OF THE ULNA FOR MALUNITED COLLES' FRACTURE*

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Recent medical literature has devoted considerable attention to the so-called dislocation of the lower end of the ulna, which is not infrequently associated with improperly reduced Colles' fracture. When consideration is given to the great variation which occurs in Colles' fracture, the observer must be impressed by the similarity of the clinical picture presented by many of these patients. They invariably complain of weakness of grasp, pain or tenderness on pressure over the lower end of the ulna, limitation of rotation, and an annoying protrusion of the ulnar head (Fig. 1). The fact that this prominence is increased on pronation or supination has led to the belief that the ulnar head has dislocated. In consequence, resection of the head[1], or even reconstruction of the inferior radio-ulnar ligaments[4], has been recommended by way of treatment.

When the roentgenograms of such cases are studied attentively, one fact stands out clearly,—there has been a reversal of the normal relationships of the radial and ulnar styloids. Instead of being above, the ulnar styloid lies at a level below that of the radial styloid. Moreover, the ulnar

FIG. 1

Showing marked prominence of the right ulna, with tendency toward radial deviation of the hand.

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styloid projects distally so far that its shadow overlaps the shadow of the proximal row of carpal bones.

This is a matter of great importance. Normally, the additional length of the radius acts to keep the carpal bones distal to the lower end of the ulna, so that rotation is not impeded. However, when the radius is shortened by impaction, the relatively longer ulna impinges against the proximal row of the carpus and interferes with rotation. This bony block acts to cause a forward dislocation of the carpus and the radius, so that relatively the ulna appears to disloeate posteriorly.

Obviously, the indieation for treatment is proper reduetion, with special attention to maintaining the relative lengths of the bones. In those cases seen after firm union and deformity have oecurred, a lengthening of the radius to restore the normal relationship of the bones would be indicated. However, as in other eases where equalization of bone lengths is necessary, it has been found simpler to shorten the normal bone than to lengthen the affected bone.

The following case is typieal of the condition and of the therapy which has been successfully employed.

J. K., aged fifteen, first seen in the Out-Patient Department in 1935, complained of pronated feet. At that time it was casually noted that the right wrist had some radial deviation. There was no limitation of motion and no other abnormality was noted. Because of the fact that the patient made no complaint of the wrist at this time, no roentgenograms were made. The patient was not seen again until November 1939, when he returned, complaining of pain in the right wrist.

The patient stated that in 1937 he had fallen a distance of six feet and had fractured the right wrist. Treatment consisted of simple immobilization, by means of a splint, for a period of about one month. The patient apparently had had no symptoms until several months previously, when he began to have pain on motion of the right wrist.

Examination disclosed radial deviation of the hand, with a definite prominence of the lower end of the right ulna, suggesting dislocation (Fig. 1). Pronation caused a marked increase in the ulnar projection. An effort to reduce the dislocation, even by marked radial deviation, was unsuccessful, and caused much pain. Ulnar motion of the hand was limited, but all other motions were free and painless. The ulna was abnormally mobile and the hand grasp was definitely weak.

The roentgenogram (Fig. 2) disclosed a separation of the forearm bones at the distal radio-ulnar articulation. The plane of the inferior articular surface of the radius deviated sharply anteriorly and medially, so that some observers were inclined to consider it as evidence of an early Madelung's deformity. The most striking feature of the roentgenogram, however, was the discrepancy in length between the two bones. The ulnar styloid obviously projected below the level of the proximal carpal row, and the ulnar head no longer articulated with the lesser sigmoid cavity of the radius.

Since the ulna had suffered no injury, it was apparent that the disproportion between the two bones was due to the fact that the lower end of the radius had telescoped into the radial shaft at the time of fracture. In fact, it was the radius which was abnormally short, rather than the ulna which was abnormally long. Clearly the indication was to restore the relative lengths of the forearm bones, either by lengthening the radius, or by shortening the ulna. The latter was chosen as being technically less complicated.

On December 5, 1939, a two and one-half inch incision was made on the ulnar side of the forearm, just above the tip of the ulnar styloid. An oblique, subperiosteal resection of three-fourths of an inch of the ulna, one inch above the ulnar styloid, was performed. The osteotomized ends of the ulna were drawn together and wired. The wound was

Fig. 2

Roentgenogram showing interference in the growth of the lower end of the radius, apparently due to a partial synostosis. The ulnar head projects below its normal level. The hand is in slight radial deviation.

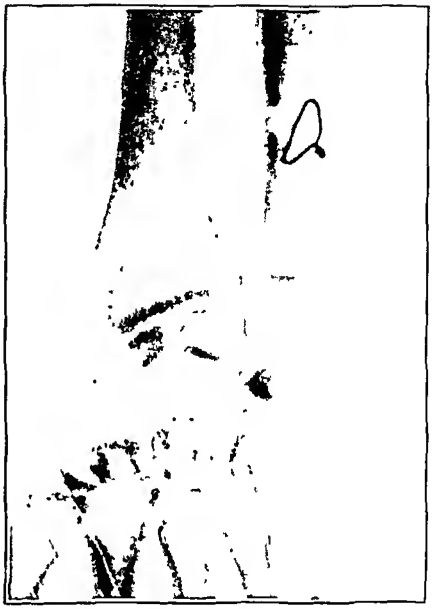

Fig. 3

Postoperative roentgenogram. The ulna has been shortened, so that its head articulates with the radius. The so-called dislocation of the ulna has been eliminated.

closed and a plaster-of-Paris bandage was applied, with the elbow in flexion and the forearm in mid-pronation. Upon removal of the plaster on December 18, 1939, union was firm. The roentgenogram (Fig. 3) showed the ulnar head articulating normally with the lower end of the radius. The prominence of the ulna had disappeared and, clinically, there was no evidence of dislocation of the ulna. Physiotherapy was instituted to restore the normal range of motion. Examination in April disclosed normal return of painless and powerful function, with complete disappearance of the annoying deformity.

This procedure has been used with success in several such cases. The report of this case emphasizes the importance of restoring the anatomical relationship of length in adequately reduced Colles' fracture, and it presents a relatively simple method of correcting a common deformity due to improper reduction of Colles' fracture.

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EPIPHYSEAL DISLOCATIONS IN SCURVY *

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Spontaneous epiphysiolysis has been noted by many clinicians in the past. Thomas Smith, in 1876, was first to recognize the complication in a case of hemorrhagic periostitis Thomas Barlow, in 1883, observed "crepitus, pseudoparalysis and gross deformities in two knees and two hips", which from the autopsy studies proved to be epiphyseal dislocations associated with skeletal hemorrhages. Since that time many references have been made to infantile scurvy and its associated epiphyseal luxations.

Clinically, the disorder is a state of hypovitaminosis C with a

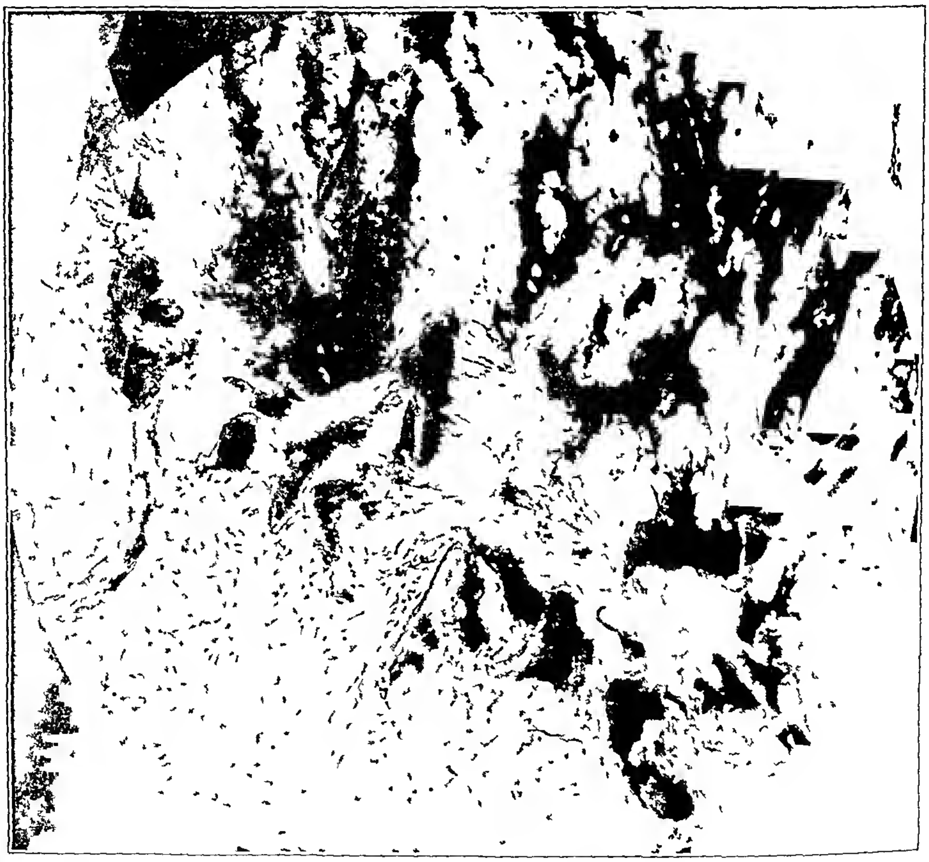

Fig 1

High-power photomicrograph of the scorbutic lattice, showing the salient pathological features of scurvy,—highly calcified bony trabeculae with many fractures, connective-tissue invasion of the marrow spaces, and the absence of normal cellular elements. (*Reproduced by courtesy of Dr. Park and The Archives of Diseases in Childhood* [4])

* Read before the Western Orthopaedic Association, Los Angeles Chapter, September 29, 1939

† Service of John C Wilson, M D.

disposition to hemorrhages and secondary anaemia. The intrinsic factors often responsible for this state are increased body demands for vitamin C, abnormal destruction by drugs such as salycilic acid, decreased absorbability, and hypersensitivity for the vitamin or its allied foodstuffs,[3] while the responsible extrinsic causes are commonly based upon the fact that ascorbic acid is not thermostabile and that it loses potency when exposed to air[2]. These etiological factors serve to explain why scurvy is present today, our knowledge of modern preventive medicine notwithstanding.

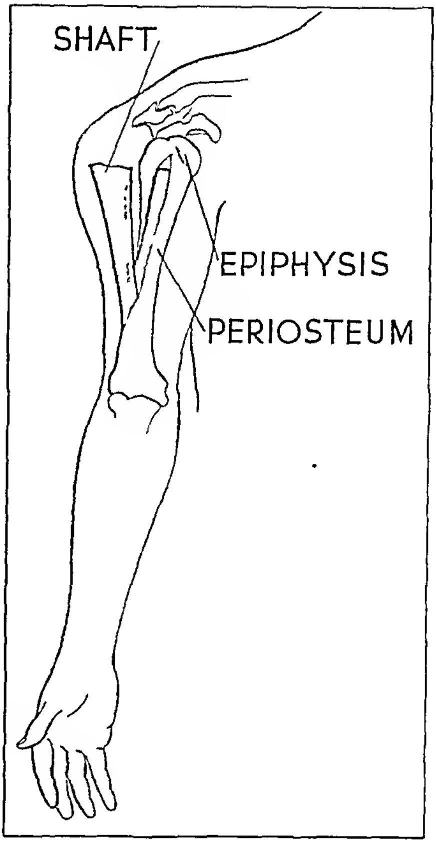

FIG. 2

Artist's drawing showing severe slipping. Note the rent and the sleevelike periosteal structure which remains for subsequent bone development. The denuded cortical shaft eventually undergoes complete resorption.

Skeletal changes appear early in the disease, although they may pass unnoticed in mild and subclinical cases. Microscopic studies are available in only the severe cases, and have been adequately recorded[4]. Osteoclastic bone resorption is speeded up through the skeleton, but is maximal in the metaphyseal ends. The cellular elements in the marrow spaces migrate, leaving a connective-tissue frame-work (*Gerustmark*). Multiple extensive hemorrhages occur by rhexis, while cartilaginous proliferation and calcification of the proliferative cartilage remain normal.

Epiphyseal fractures are a "late and very severe phenomenon" [1]. Barlow, from the pathological studies of his fatal cases made for him by Money, wrote, "I would suggest that the subperiosteal blood extravasation is the first event and the fracture the second. The extensive blood extravasation probably interferes with the nutrition of the bone, and thus the very minimum of violence, such as an ordinary movement, may lead to fracture".

While these early observations are true, it remained for more recent workers to show that the separation of the epiphysis from the metaphysis is always through the zone of calcified cartilage known as the scorbutic lattice (Fig. 1), which, in the roentgenogram, is represented by a narrow band of increased density known as the white line of scurvy or *Trümmerfeld* (Fig. 4-A). Because of its high lime content it is vulnerable to the stresses of body motion. Microscopic fractures, legion in number,

Fig. 3-A

Case 1. Roentgenogram taken March 10, 1939, showing anteroposterior view of both shoulders taken six days before admission to the Children's Hospital. Note the complete separation of the epiphyses from the shafts of the humeri, and absence of hematoma shadows.

appear spontaneously throughout the lattice (Fig. 1), very early in the clinical course of the disease, and are a consistent feature of the local pathology.

Simultaneously with the occurrence of lattice fractures, hemorrhages appear under the periosteum, and stripping takes place with little resistance; thus the last stronghold of epiphysiodiaphyseal integrity is lost. The intact periosteum maintains a "periosteal cuff" across the epiphyseal line which, clinically, is found to be a resisting factor against any displacement. If one removes the periosteum from a long bone of a young rabbit, the ease with which the epiphysis can be broken off is remarkably increased It would appear, therefore, that several factors lead to epiphyseal dislocations in scurvy: (1) spontaneous lattice fractures as pointed out by Park, and (2) subperiosteal hemorrhages, with periosteal stripping from the shaft particularly from the periphery of the epiphyseal plate (loss of the periosteal cuff).

Our case reports and serial roentgenograms illustrate the startling degree to which the infant skeleton can adjust itself to deformities by the systematic process of bone production and resorption. According to a predictable plan, new bone is laid down by periosteal bone formation on the side of the shaft toward which the epiphysis has been displaced and, to a lesser degree, on the opposite side. The epiphysis, therefore, becomes centered at the end of a newly widened metaphysis and maintains that central position throughout the secondary stage of bone resorption which ultimately shaves the bone down to its original size and shape.

The more marked dislocations are repaired by a slightly different process which is illustrated by the roentgenograms of Case 2. Figure 2 illustrates the expulsion of denuded cortical bone from its periosteal covering through a large rent. A new shaft is formed within the periosteal

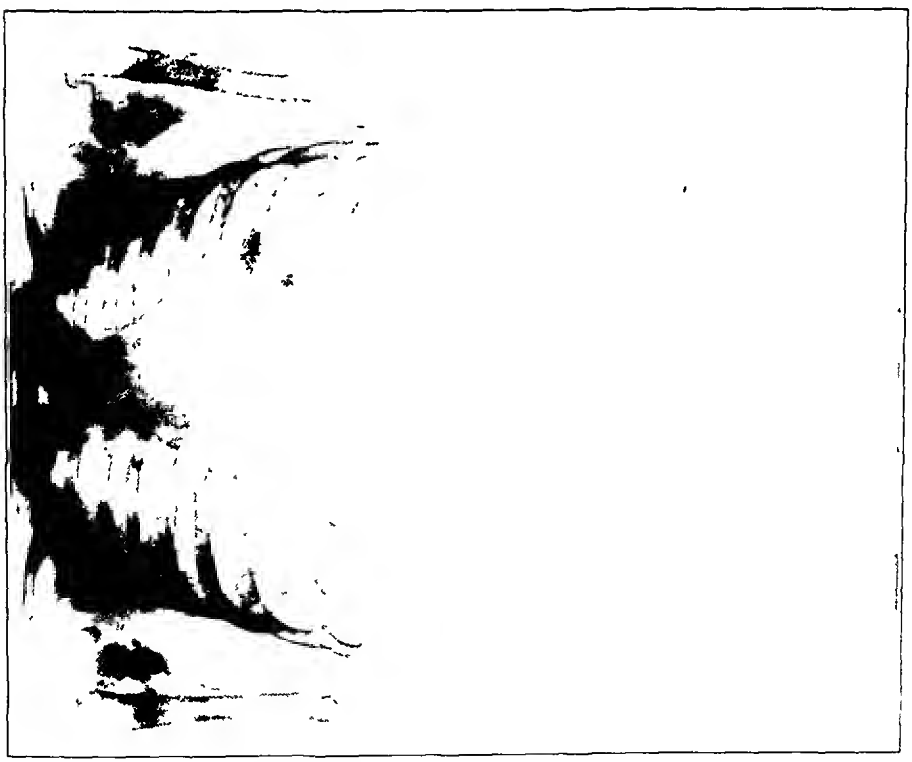

Fig. 3-B

Case 1. Roentgenogram taken April 17, 1939, four weeks after administration of ascorbic acid. The relation between the shafts and epiphyses is not altered from that of the original x-ray.

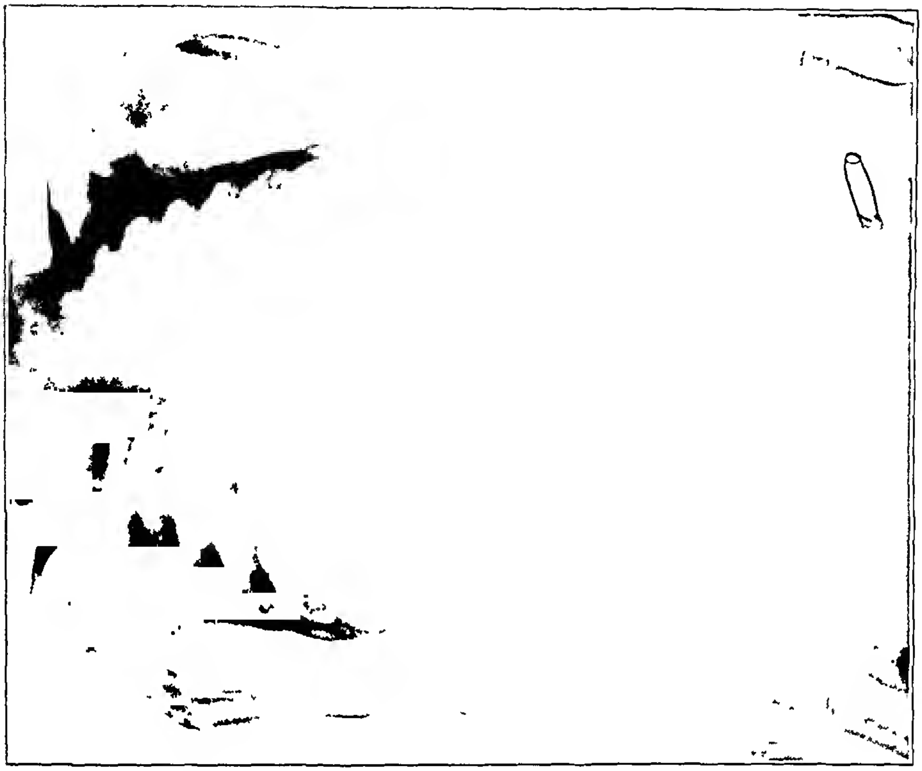

Fig. 3-C

Case 1. Roentgenogram taken June 9, 1939. Absorption of the protruding metaphysis is well advanced, and the remaining periosteal cuff is filled in quite completely. Function of the shoulder is good at this time.

FIG. 3-A

Case 1. Roentgenogram taken March 10, 1939, showing anteroposterior view of both shoulders taken six days before admission to the Children's Hospital. Note the complete separation of the epiphyses from the shafts of the humeri, and absence of hematoma shadows.

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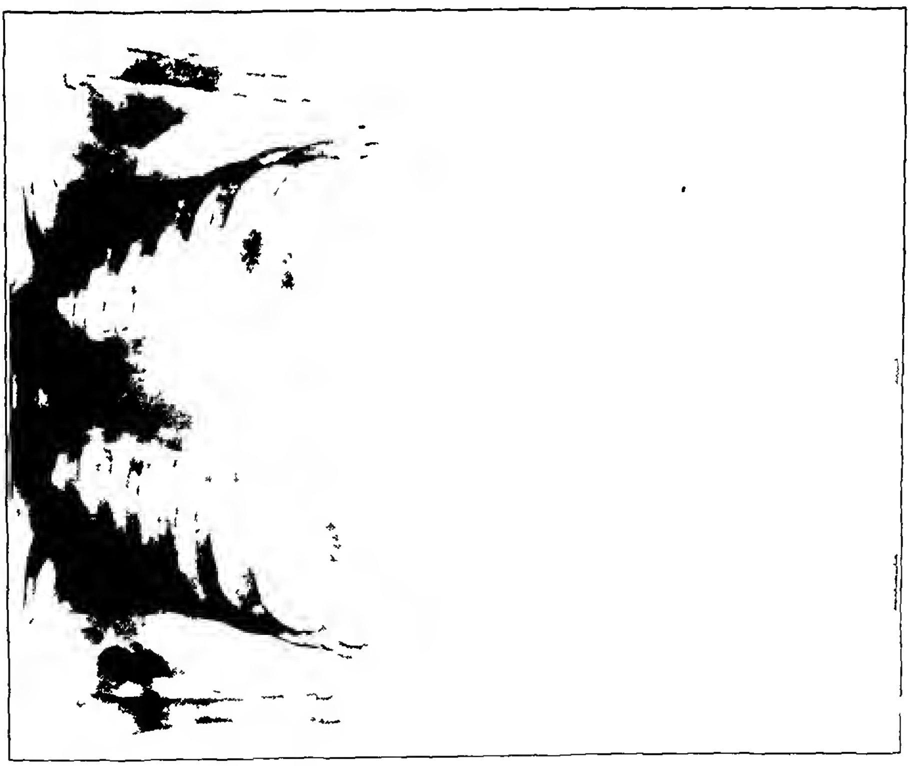

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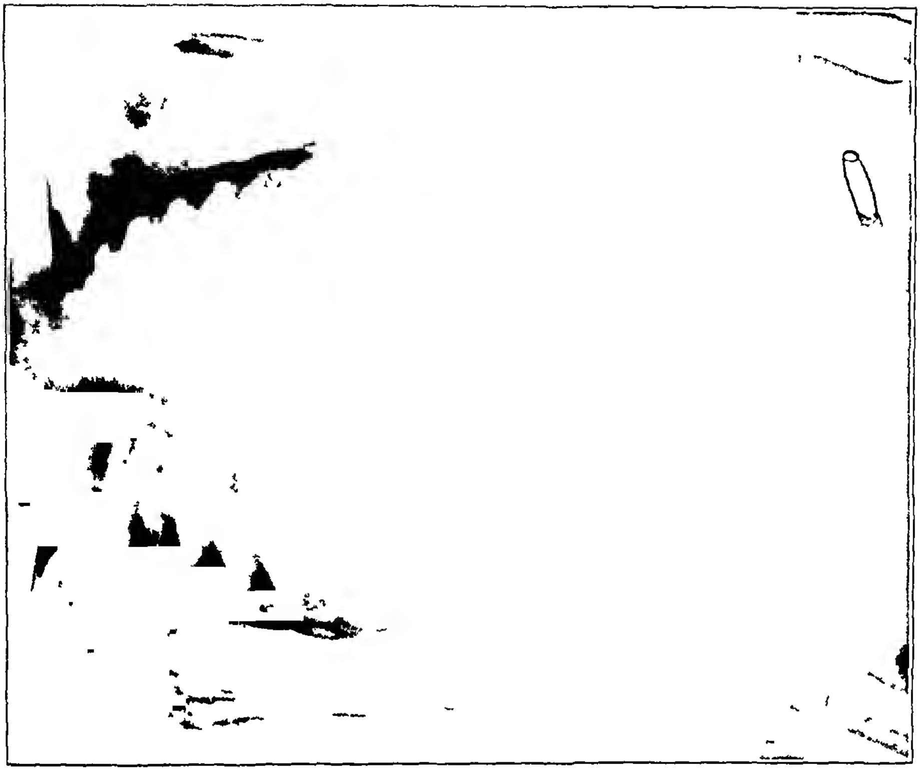

Fig 3-C

Case 1 Roentgenogram taken June 9, 1939 Absorption of the protruding metaphysis is well advanced, and the remaining periosteal cuff is filled in quite completely. Function of the shoulder is good at this time.

sleeve, while the protruding shaft undergoes rapid resorption. For a time the new and old shafts are at an angle to each other, but in due course this angulation may be expected to disappear.

The usual locations for these epiphyseal fractures are the lower femur, upper humerus, costochondral junctions, and lower tibia, in order of frequency. Recently, Sabin found epiphyseal fractures in scorbutic monkeys, which were most marked in the lower femur and the costochondral junctions.

Some observers, particularly the roentgenologists, have endeavored to read early diagnostic signs into their x-rays, while others fail to recognize any of the bone changes as early. A history of dietary insufficiencies, the capillary fragility test, saturation determinations by the test-dose method, clinical response to treatment, coupled with oedema, spongy gums, and irritability, in a child between six and twelve months of age, will usually serve to make the diagnosis before roentgenograms become

FIG. 3-D

Case 1 Roentgenogram taken October 3, 1939. Further ossification and decrease in the angulation of the shaft.

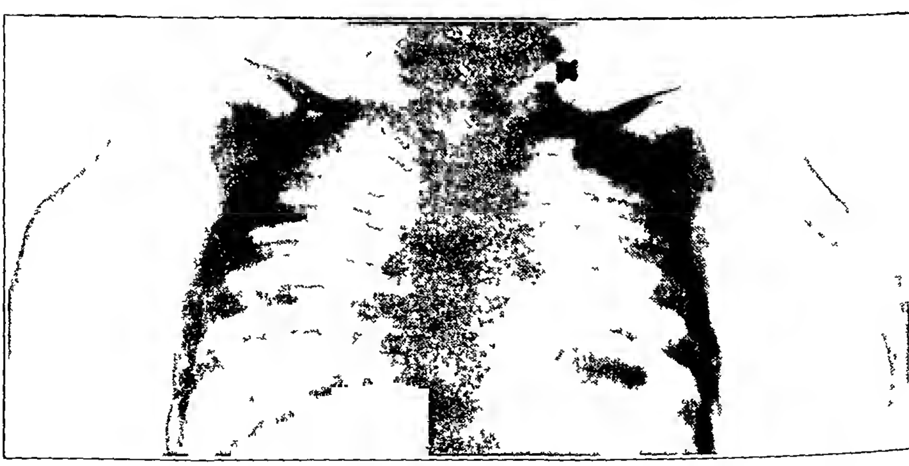

FIG. 3-E

Case 1. Roentgenogram taken January 12, 1940, shows complete clinical cure without disability.

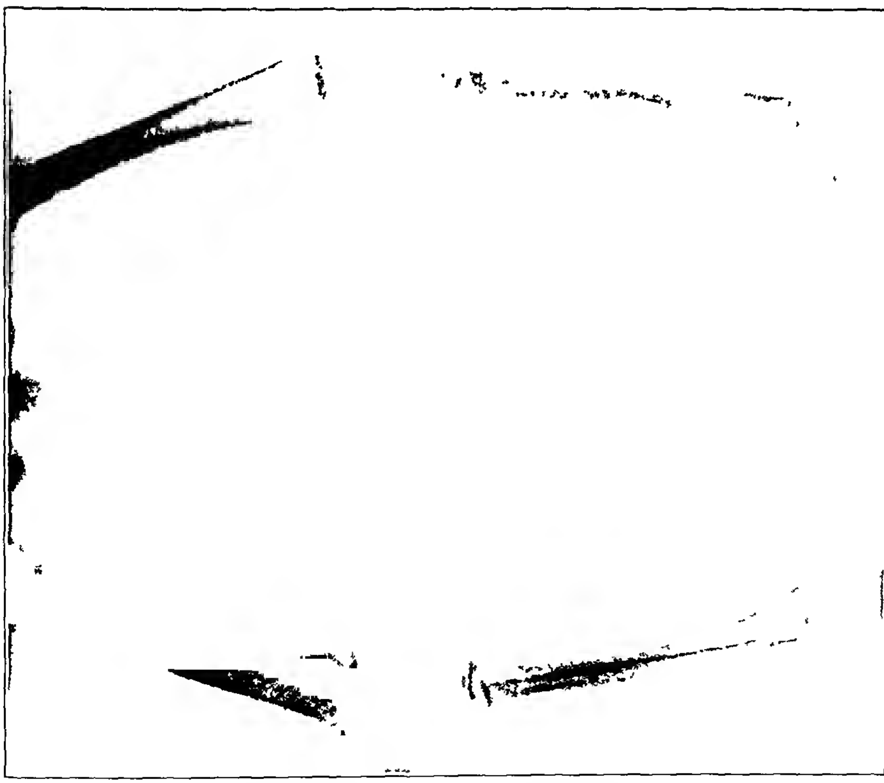

FIG. 4-A

Case 2. Roentgenogram taken February 4, 1939. Anteroposterior views of both legs show signs of florid scurvy with typical dark (white in original X-ray) lines involving all epiphyses, especially of the lower femur and lower tibia. There are no hematoma shadows.

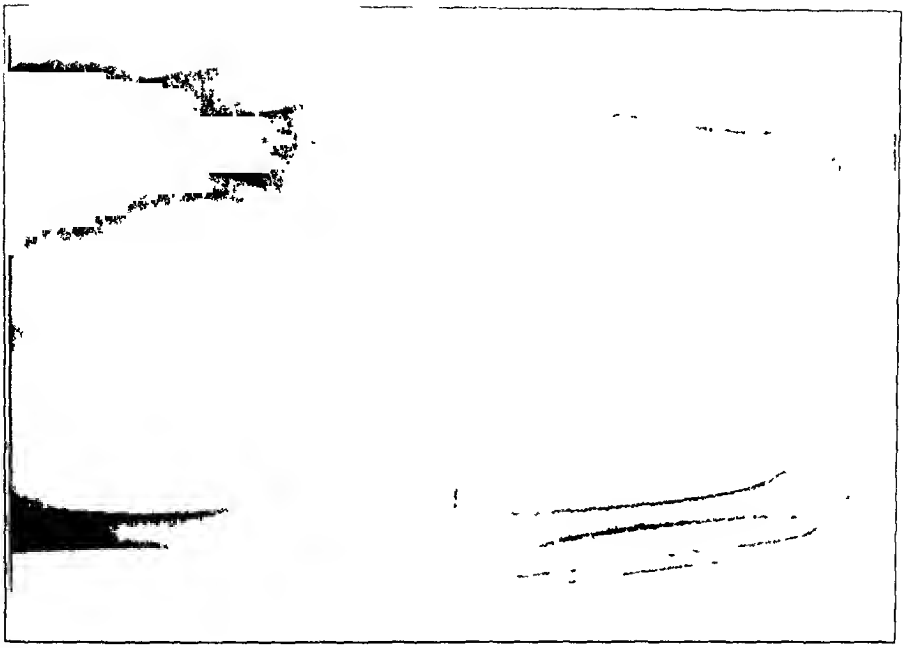

FIG. 4-B

Case 2. Roentgenogram taken February 13, 1939, nine days after the beginning of ascorbic-acid therapy. Lateral slipping of the femoral epiphyses can be noted. Calcification is taking place in the subperiosteal hematoma.

positive. Only one roentgenographic sign, when present, is conclusive and that is the white line with a zone of rarefaction in juxtaposition to it. The subperiosteal hematomata become calcified only after vitamin C is supplied, and a period of ten days is required for such changes to take place in the clot. A subperiosteal hematoma, when visible in the roentgenogram, is, therefore, indicative of the healing stage, and thus is a late phenomenon. Epiphyseal dislocations and subluxations likewise appear late. Calcified subperiosteal hematomata and dislocated epiphyses are not pathognomonic signs of scurvy unless they are accompanied by the scorbutic white lines. Unless this important finding be present, traumatic epiphysiolysis cannot be ruled out.

The differential diagnosis in a given case should not be difficult in the light of available diagnostic tests and roentgenographic details. Parrot's disease, congenital dislocations, and Albers-Schönberg disease, may in certain respects simulate the local findings. Traumatic dislocations can be differentiated by the absence of white lines; in other

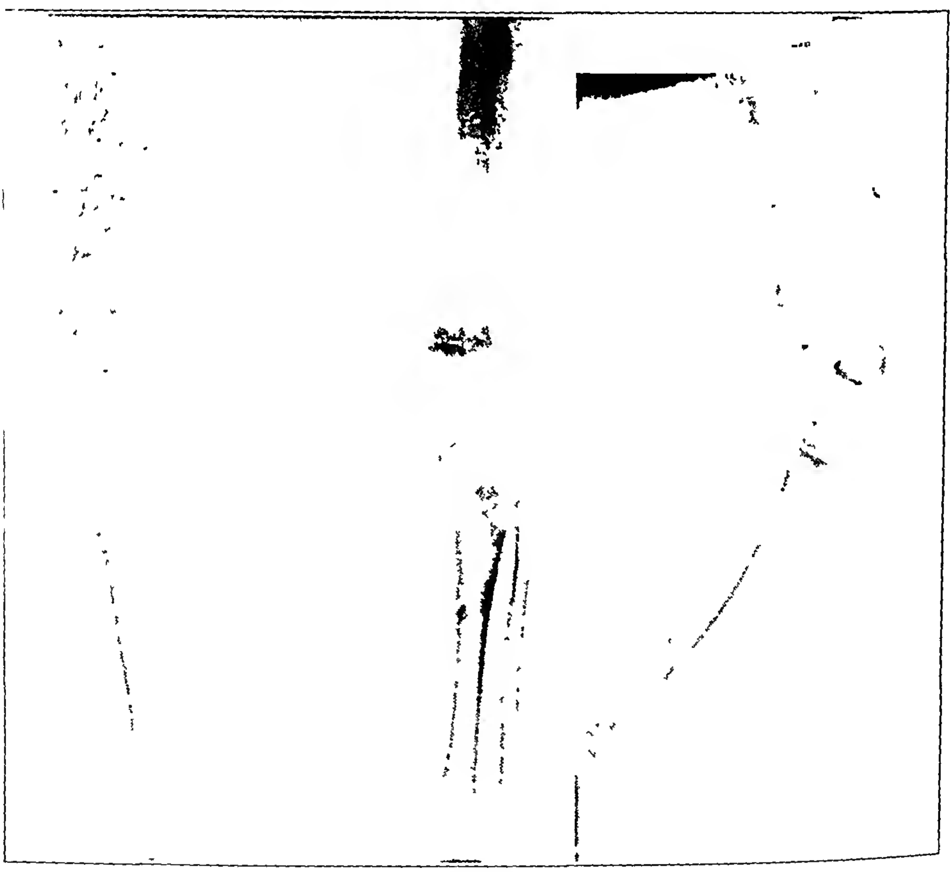

Fig. 4-C

Case 2. Roentgenograms taken March 14, 1939. New bone is laid down by periosteal bone formation on the side of the shaft toward which the epiphysis has been displaced, and, to a lesser degree, on the opposite side. The epiphysis, therefore, becomes centered at the end of a newly widened metaphysis and maintains that central position through the secondary stage of bone resorption which ultimately shaves the bone down to its original size and shape.

roentgenographic respects the two types may be identical.

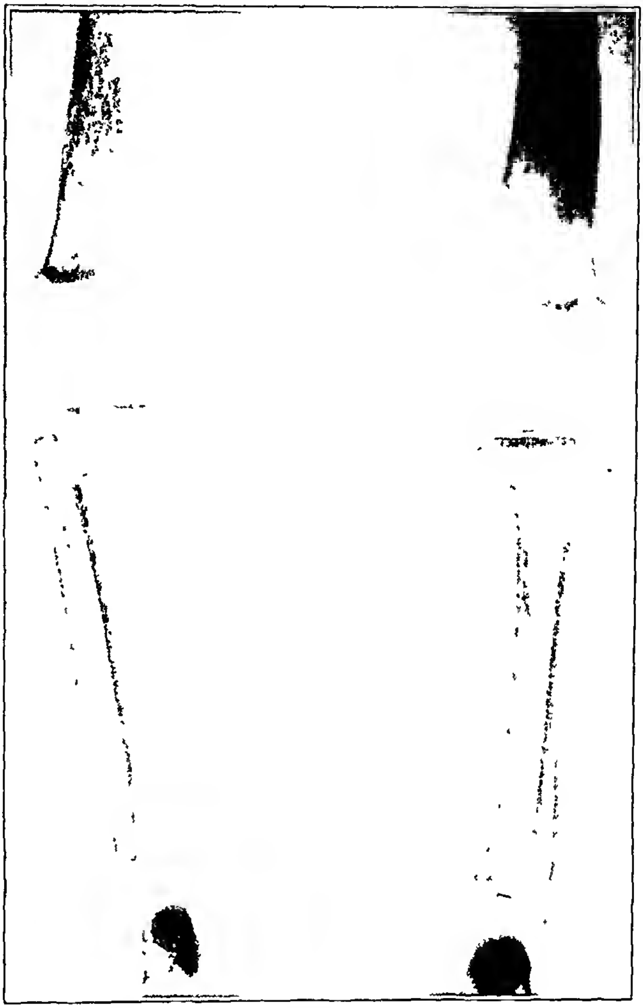

Fig. 4-D

Case 2. Roentgenogram taken October 11, 1939, shows complete clinical healing. Function is perfect.

Case 1. Baby L., Mexican, aged eleven months, was admitted to Children's Hospital, Los Angeles, California, on March 16, 1939, with complaints of bleeding gums of four days' duration, a head cold of six weeks' standing, and marked irritability when handled. A few days prior to admission, a bilateral shoulder spica had been applied for fractures near the shoulders. The past history revealed that the child had never had orange juice, cod-liver oil, or vegetables. Examination showed an irritable, sick-looking child with a head cold. The gums were hemorrhagic, the costochondral junctions were sharp, and the shoulders showed visible deformities. The red-blood-cell count was 2,700,000, and the white-blood-cell count, 14,000. There was a moderate temperature. Treatment consisted of removing the cast and supplying a diet rich in vitamins. This included orange juice and 300 milligrams of ascorbic acid daily. General improvement was dramatic. Orthopaedic consultation was given, but no special recommendations were made for treatment, because it was agreed that the prognosis for the shoulder disabilities was good. The patient was discharged on April 17, 1939, on a prescribed diet and 25 milligrams of ascorbic acid daily. Figures 3-A, 3-B, 3-C, 3-D and 3-E show the progress as evident in the roentgenograms.

Case 2. Baby M., female, aged nine months, was admitted to Children's Hospital, February 4, 1939, complaining of a sore left leg of two months' duration. On examination the child was described as irritable and fussy. Fresh blood was found in one auditory canal, as well as along the gum margins. The child resented any passive motions of the left lower extremity, which presented a visibly swollen ankle and knee. The red-blood-cell count was 4,900,000, the white-blood-cell count, 18,000, and hemoglobin 75 per cent. Treatment consisted of ascorbic acid in 75-milligram doses daily. A high vitamin, high caloric diet was prescribed. The child was discharged on February 18, 1939, in good general condition. The healing process is shown by progressive roentgenograms (Figs. 4-A, 4-B, 4-C and 4-D).

CONCLUSIONS AND SUMMARY

1. Scorbutic epiphysiolysis is rare in infancy.
2. Microscopic lattice fractures and the loss of the "periosteal cuff" are the factors responsible for the slipping.
3. A natural realignment of shaft and epiphysis takes place following the use of vitamin C, which leads to recovery without deformity or disability.

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POLYOSTOTIC FIBROUS DYSPLASIA WITH CUTANEOUS PIGMENTATION AND CONGENITAL ARTERIOVENOUS ANEURYSMS

A Case Report

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Fibrous dystrophy involving multiple bones has been differentiated in recent years from localized and generalized osteitis fibrosa cystica.[1, 9] Lichtenstein believes it represents a distinct clinical entity and has proposed the term "polyostotic fibrous dysplasia". Three further cases have appeared under this designation.[7, 10, 13] A syndrome with similar bone pathology, cutaneous pigmentation, and precocious puberty in females has been described by Albright and his coworkers[2, 3] and others.[4, 8, 12, 14, 15, 16] A case has been studied which presented predominantly unilateral fibrous replacement of bone, and cutaneous pigmentation. Multiple arteriovenous aneurysms were located in those extremities showing the most marked bone involvement.

CASE REPORT

History

G. B., male, aged nineteen years, was admitted to Temple University Hospital on the Service of Dr. Temple Fay on April 13, 1940, because of protrusion of the left eye of two weeks' duration. There had been brownish discoloration of the left upper eyelid, lacrimation, and pain shooting to the vertex on closing the eye. On admission, these had diminished, and the proptosis was receding.

The past medical history revealed the usual childhood diseases. The family history was negative. The patient came of northern European stock. Early development was normal. A triangular brown area was present on the back from birth.

At two and one-half years of age trauma to the left forearm was followed by enlargement and bowing. At five years, after a minor injury, protrusion of the left forehead was first noted. At this period, following roentgenographic study, a diagnosis of "bone cysts" was made. The left femur was fractured twice during the sixth year, resulting in deformity of the hip and a persisting limp. At eleven years there was a fracture of the neck of the left femur. Bone deformity of the left upper extremity progressed gradually, chiefly from the eighth to the twelfth years, with an increase in the diameter of the arm. Minor trauma usually preceded the development of the enlargements, which frequently were painful at the outset.

Prominence of the veins of the left upper extremity had been present since early childhood, and the parents had become aware of unusual vibrations palpable over it when he was about ten years of age. At that time a roentgenologist stated that the boy's heart was greatly enlarged.

A biopsy was made from the proximal end of the left radius at another hospital when he was eleven years of age. The pathological diagnosis was osteitis fibrosa cystica. On that basis, exploration of the neck was carried out, and a small parathyroid gland re-

FIG. 1

Photograph showing deformities of left side of body and proptosis of left eye.

moved, which was reported histologically normal. Subsequently, a series of roentgen-ray treatments of the parathyroids was given. The patient felt that there had been little progression of his deformities since the parathyroidectomy.

Puberty had occurred at about the normal time and sexual desire was normal. The cardiorespiratory, gastro-intestinal, genito-urinary, and nervous systems were essentially negative. Growth and weight gain were normal. Despite limitation of activity due to the deformities, he had been graduated from high school. His intelligence was well above average, and he had developed sufficient manual dexterity to undertake drafting as an occupation.

Physical Examination

The patient was somewhat underdeveloped, measuring five feet five inches in height and weighing 113 pounds. Obvious deformity was confined almost entirely to the left side (Fig. 1). Bony enlargement of the left frontal region and left lower jaw was present. The left arm was greatly increased in diameter and showed a posterior bow; the forearm was increased in diameter in its upper third, and the hand was greatly distorted. The deformities and resulting ankylosis rendered this extremity practically useless. In the right upper extremity, slight swelling of the proximal third of the arm, of the elbow, and several small bones of the hand was the only apparent involvement. The left hip was prominent, showing coxa vara deformity and partial ankylosis. The diameter of the upper third of the thigh was increased. On the left there were genu valgum and 10 degrees' back-knee, with cavus deformity, and equinus of the foot. There was three centimeters of shortening on the left, the patient walking with an obvious limp on this side. The right lower extremity was normal. A marked lumbar scoliosis, convex to the right, was present.

The skin was pallid. It was smoother and warmer over the left arm and thigh. In the same areas the hair was more sparse and downy. Distribution of hair was normal otherwise, except for scanty growth on the face. A triangular, coffee-colored, non-elevated area of pigmentation was located on the lower posterior thorax, just left of the midline (Fig. 2).

The left eye was proptosed with lacrimation and conjunctival oedema. The extra-ocular movements were limited in all directions. Fundal examination showed beginning oedema of the left disc. Perimetry revealed only a relative central scotoma on the left. Vision: left eye 6/15; right eye 6/12. Examination of the nose and ears was negative. Audiometer readings showed bilateral mixed deafness. Bárány findings were normal. The teeth were normally developed. The thyroid gland was not enlarged.

The heart was greatly enlarged, with a forceful apical thrust. The apex beat was

palpable in the fifth interspace, eleven centimeters from the midsternal line. The left border was percussed at the anterior axillary line in the fifth interspace. A harsh basal systolic murmur was best heard in the second left interspace. On compression of the left axillary and femoral arteries, the murmur diminished perceptibly, together with slowing of the pulse rate from eighty to sixty per minute. This "bradycardiac phenomenon" was abolished by one-thirtieth of a grain of atropine sulphate given intravenously. It was accompanied by a reduction in the amplitude of cardiac pulsations, as revealed by fluoroscopy. The latter showed enlargement of all chambers of the heart with a computed volume of 925 cubic centimeters. The electrocardiogram was normal. The blood pressure in the recumbent position was 150/90 in the right arm, and 160/0 in the left. Thrills and continuous bruits with systolic accentuation were present above the left clavicle and throughout the left arm, especially over the larger arteries. There was also a thrill and bruit over the left femoral artery just below the inguinal ligament. The veins of the left arm were greatly dilated and tortuous, the larger ones showing systolic pulsations (Fig. 3). Oscillometric readings showed abnormally great amplitude of pulsations over the left arm, forearm, and thigh. Venous-pressure determinations gave equivocal results. Sodium-cyanide circulation times were: right arm, 15.8 seconds; left arm, 11.2 seconds; and right femoral vein, 9.2 seconds. Skin-temperature readings over the left arm averaged from 1 to 3 degrees Fahrenheit higher than on the right. Sweating occurred more readily over the left arm than elsewhere following pilocarpine (The development of blue color in a starch-iodine mixture was used as an indicator).

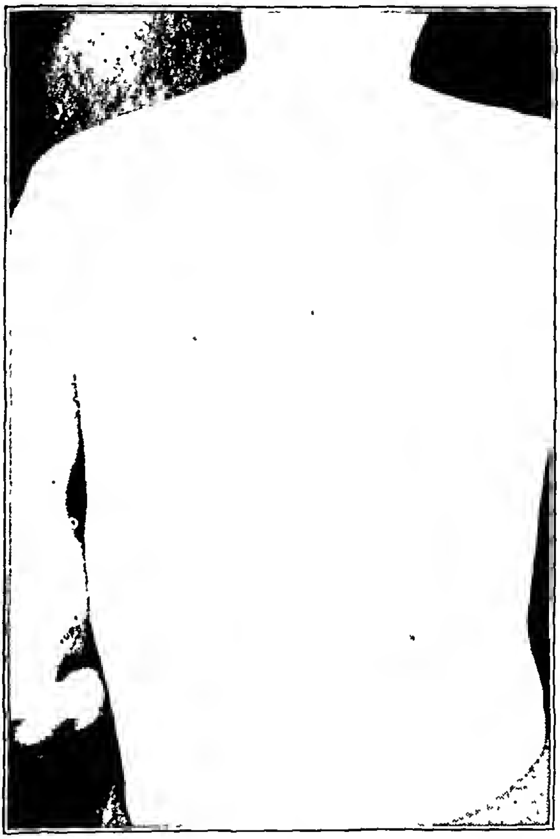

FIG. 2

Photograph of back showing pigmented area to the left of the midline.

The abdomen and genitalia were essentially normal. Rectal examination was negative. Neurological examination revealed nothing significant except an equivocal Chvostek's sign.

Roentgenographic Findings

Examination of the skeleton revealed most of the bone structures to be involved by an unusual process. The bone changes were all of the same type but differed in degree and extent, and, apparently, in duration at various sites. While the lesions were predominantly on the left side of the body, there were similar, but less well-advanced, changes on the right side, exclusive of the lower extremity.

The skull (Fig. 4) showed marked thickening of the frontal bone with marked irregularity in density. The frontal sinus had been replaced by expanded, coarsely trabeculated bone. The bone structures along the floor of the anterior and middle

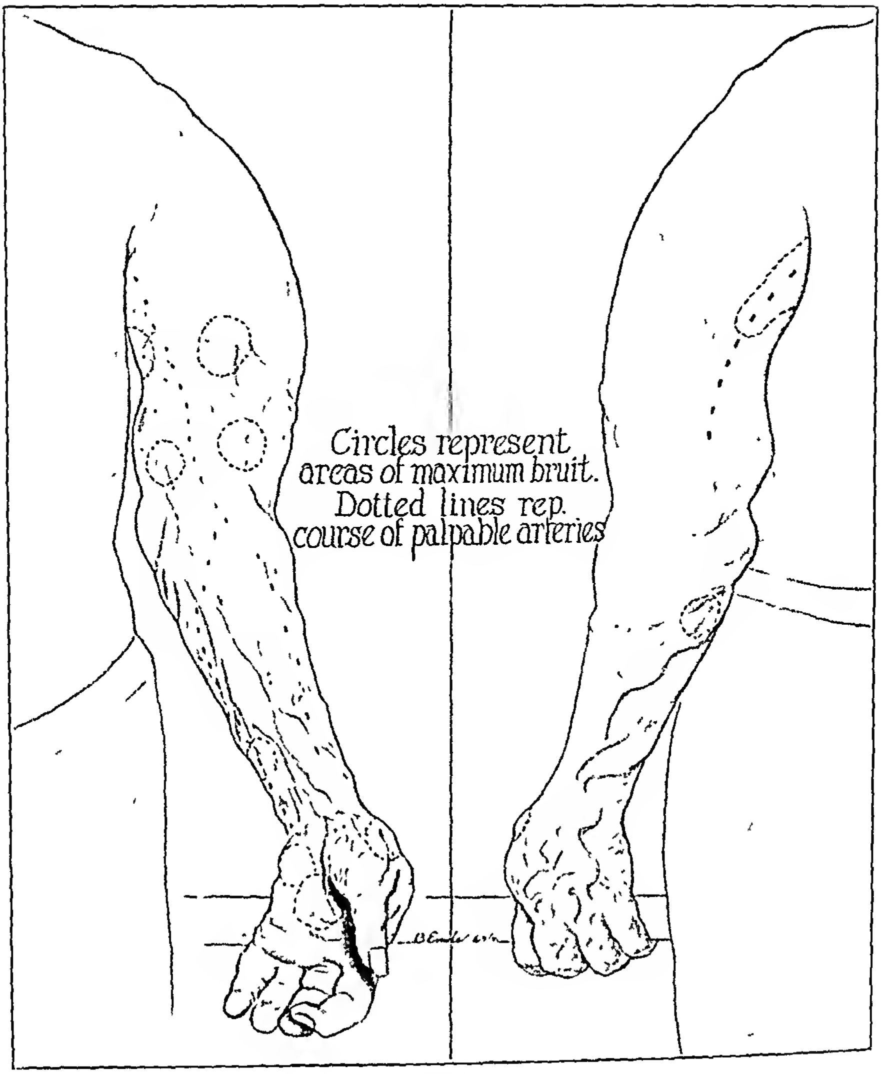

FIG. 3

Drawing of left upper extremity showing dilated veins and indicating course of palpable arteries with the sites of maximum bruit.

fossae were involved, but the posterior part of the skull appeared normal. The involvement on the left side was much more extensive.

The left humerus (Fig. 5) was greatly expanded, and the cortex was thin and irregular. Bowing was present. The medullary portion of the bone showed coarse, irregular trabeculations of increased density, intermixed with less dense areas simulating cysts, but stereoscopic study failed to reveal any evidence of a cyst wall.

The hands (Fig. 6) showed involvement, more marked on the left side. The bones were expanded and the cortex greatly thinned, but there was no evidence of perforation of the cortex at any site. Marked irregularity in density of these bones was noted. The trabeculations were prominent and ran at all angles, thus simulating cysts, but no true cysts could be demonstrated.

The pelvis (Fig. 7) revealed marked asymmetry with the distortion confined to the left side. Softening and molding of the pelvis in the region of the acetabulum had deformed these structures, and the acetabular fossa was very shallow. There was marked shortening of the left femur contributed to by the marked angulation between the neck and shaft of the femur, and by the coxa vara deformity.

In addition to the areas illustrated, the left lower extremity, the right upper extremity, the mandible, several ribs, and several vertebrae also showed involvement.

Laboratory Data

In determinations on finger blood from both hands the hemoglobin was 9.5 grams per 100 cubic centimeters and the red blood cells 4,230,000 per cubic millimeter. Differential and platelet counts, sedimentation rate, prothrombin, and coagulation times were normal. There was no Bence-Jones protein or other abnormal finding in the urine. Blood and spinal-fluid serology, and the tuberculin test were negative. Basal metabolic rate, gastric analysis, Mosenthal test, urea clearance, and glucose tolerance all were within normal limits.

Oxygen saturation of venous blood * in the right forearm was 34.8 per cent., in the left forearm, 90.2 per cent.

No anterior pituitarylike hormone or estrone was detected in two forty-eight-hour urine specimens. In two twenty-four-hour specimens there were 7.0 milligrams and 4.0 milligrams respectively of androgens, calculated as androsterone, by the method of Callow, Callow, and Emmens.[5]

(In several determinations between September 8, 1932, and August 20, 1934, at another hospital, the serum calcium had been reported as between 9.2 and 12.5 milligrams per 100 cubic centimeters; and the phosphorus between 2.3 and 3.9 milligrams per 100 cubic centimeters.)

In weekly determinations the serum-calcium level was between 7.0 and 9.0 milligrams per 100 cubic centimeters; the phosphorus between 3.6 and 4.6 milligrams per 100 cubic centimeters. The phosphatase activity ranged between 37.6 and 64.0 Bodansky units, except for an isolated value of 132 units. Blood sugar, urea nitrogen, non-protein

* Oxygen-saturation determinations were done by Dr. Robert H. Hamilton, Department of Physiological Chemistry.

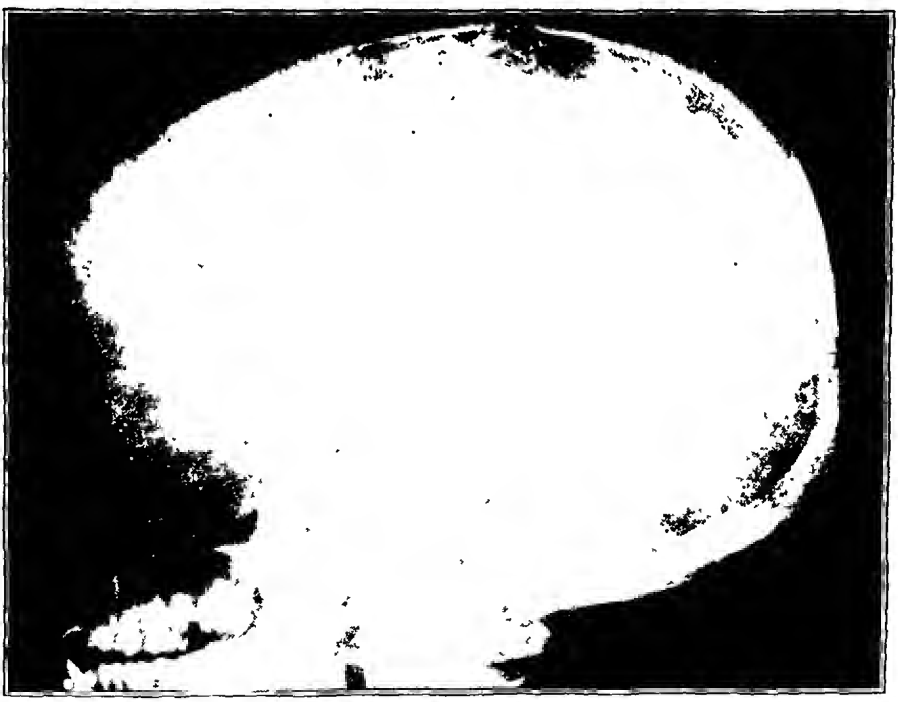

Fig. 4

Roentgenogram showing characteristic bone lesions. (See also Figs. 5, 6, and 7.)

FIG. 5

nitrogen, chlorides, cholesterol, and cholesterol esters were within normal limits.

Two six-day calcium-balance studies were essentially normal. On a calcium intake of approximately 0.1 grams daily the output averaged 0.01 grams in the urine, and 0.14 grams in the faeces daily. On a daily intake of approximately 0.9 grams the output averaged 0.01 grams in the urine, and 0.30 grams in the faeces daily.

The smear from a sternal puncture revealed no gross abnormality of marrow cytology.

Course in Hospital

The patient was ambulatory throughout his stay of nine weeks. The proptosis receded spontaneously, and the eye had regained normal appearance by the end of the third week. The extra-ocular movements were also restored to normal, and the oedema of the left disc was no longer present. During the first week the blood pressure in the right arm remained about 160/100; from that time until discharge it was consistently about 120/70. The spinal-fluid pressure was twenty millimeters of mercury in the first week and eight millimeters in the third week. No adequate explanation was found for these changes. There was no other evident alteration in his clinical condition.

Treatment

The hypochromic anaemia failed to respond to ferrous sulphate in adequate dosage. Ertron (200,000 U. S. P. Vitamin D units daily) was given from May 27, 1940, to June 15, 1940, and dicalcium phosphate (3.0 grams daily) from June 4, 1940, to June 15, 1940, with no significant effect on the serum level or urinary output of calcium.

Pathological Report

Biopsy specimens were taken from the greater trochanter of the left femur, from the right ulna, and right humerus June 8, 1940,* and from the area of pigmented skin. Grossly, the bone specimens consisted of elastic, gritty tissue covered by a very thin layer of cortex. Sections presented very similar microscopic pictures (Fig. 8). Where the compact cortical bone was intact it appeared thin, and in some places was degenerating. Despite the loss of normal cortical bone there was very little evidence of osteoblastic activity of the periosteum. It was impossible to distinguish between the medullary and spongy portions. Both these zones were replaced by a fibrous matrix in which were embedded irregular spicules and fragments of degenerating bone, imperfectly calcified bone, and osteoid tissue.

Bone spicules in all stages of disintegration were found. The location of this ma-

* Bone biopsies were performed by Dr. John Royal Moore, Department of Orthopaedic Surgery.

Fig 6

Fig. 7

terial showed little relation to the presence of giant cells. The spicules identified as bone were often heavier, more irregular than normal, with spotty calcium deposition and a fairly normal surrounding membrane of osteoblasts in specially stained tissue. The greater proportion of differentiated tissue, however, was composed of irregular spiculelike pieces of osteoid or fibrous bone tissue. This material showed little inclination to calcify

Fig. 8

Photomicrograph of a section of bone biopsy from left greater trochanter showing typical fibrous dysplasia with poorly formed and degenerating bone

The entire background consisted of a fibrouslike tissue of varying density composed in a few areas of cells loosely and haphazardly placed, showing the morphology of fairly young osteoblasts. More generally, the cells were definitely spindled, the nuclei relatively pyknotic, and arranged in bundles resembling more adult fibrous connective tissue. The presence of large amounts of collagen was demonstrated by special staining. There were fewer blood channels in this tissue than in normal spongy bone, though the tissue was by no means avascular. In the majority of the fields osteoclasts or giant cells were lacking. In some areas, however, these cells were present in sufficient numbers to suggest the histology of a benign giant-cell tumor, and usually contained more than a dozen nuclei which were arranged in the center of the cell without pattern. Mitotic figures were found in none of the cells. No lipoid deposits or significant collections of inflammatory cells were seen. The whole suggests a diffuse fibrous dysplasia which has upset normal bone architecture and growth. There was both osteogenesis and osteolysis, yet neither process appeared to be normal. Comparison of sections of this tissue with those of a bone biopsy taken eight years ago in another hospital presented essentially the same picture, except that in the latter more of the fibrous cells appeared to be younger, suggesting a more active phase of the disease.

A section made of the biopsy removed from the pigmented skin showed an entirely normal histology except for an abnormal amount of pigment which was concentrated in the basal cells and deeper layers of the stratum spinosum. This resembled the histology encountered in sections of the pigmented areas from cases of von Recklinghausen's neurofibromatosis.

The section of the parathyroid gland taken at about the time of the first bone biopsy showed a moderate secondary hyperplasia. The chief cells were normal in size, though increased in number, and showed a tendency to an acinic arrangement. Fat and oxyphil cells were lacking. The lack of oxyphil cells may be due to the age of the patient when the biopsy was taken. The rest of the picture is entirely compatible with a diagnosis of secondary hyperplasia as described by Castleman and Mallory [6].

DISCUSSION

The findings in this ease eliminated generalized osteitis fibrosa eystiea, osteitis deformans, Ollier's dysehondroplasia, and neoplasm. To explain the bone disorder there remained the eondition variously called osteodystrophia fibrosa, regional fibrocystic disease, osteitis fibrosa in multiple foei, ete. Lichtenstein's deseriptive term, polyostotic fibrous dysplasia, seemed peculiarly appropriate for this typieal ease in view of the widespread distribution of the lesions. The condition is characterized as follows:

1. *Clinical Picture:* Deformity, pain, and limp usually appear in childhood or early adult life. Pathological fractures, frequently with delayed union and malunion, bowing of weight-bearing bones, and coxa vara are common. Involvement tends to be unilateral. The process progresses slowly over many years, eventually becoming static.

2. *Roentgenographic Findings:* Any of the bones may be involved, the most frequent being the femur, tibia, humerus, and radius, in the order named. The diaphysis and metaphysis are regularly affected, the epiphysis more rarely. The shaft is expanded, with the cortex markedly thinned. There are numerous irregular, apparently trabeculated areas of decreased density, commonly misinterpreted as cysts. Sometimes, especially in the radius or tibia, diffuse evenly distributed porosity with a paper-thin cortex may be seen.

3. *Chemistry:* The serum calcium is normal or slightly elevated. Calcium-balance studies have, for the most part, yielded normal results. The serum phosphorus is normal. Significant elevation of the phosphatase level is frequent.

4. *Pathology:* Thinning of the cortex is obvious grossly, the medullary cavity being occupied by solid, resilient, gritty fibrous tissue. Cysts are infrequently found. Microscopically, relatively avascular fibrous tissue replaces the cancellous bone and marrow. Trabeculae of imperfectly calcified new bone and osteoid tissue are scattered through this fibrous matrix. Periosteal deposition of new bone is not obvious, and the endosteal surface is eroded. Areas of giant cells may be found and occasionally islands of hyaline cartilage. There is no histological evidence of inflammation or neoplasia. The histological picture of the bone probably is not specific for this disease. In biopsy sections of cases of osteitis fibrosa cystica, benign giant-cell tumor, and in some instances, perhaps, osteitis deformans, the histology may be similar.

Instances of similar lesions involving a single bone have been described.[9] These may represent a monostotic variant or a stage in the evolution of the disease. There is also the possibility that lesions in other bones have been overlooked.

This case differed in one particular from the typical case as described above. The serum calcium was persistently low during hospitalization. Eight years before, prior to parathyroidectomy, and during two years thereafter it was reported normal. This might suggest that mild hypoparathyroidism had developed. It is more likely that considerable variation in the serum-calcium level may occur in the individual case, depending on the activity of the bone lesions.

It seems worthy of mention that many of the cases in the literature were also subjected to exploratory operation for parathyroid adenomata and some to parathyroidectomy before the nature of the condition was recognized.

The skin pigmentation relates this case to those of Albright and his coworkers, McCune and Bruch, and others [2, 3, 4, 8, 12, 14, 16] which had bone lesions apparently representing polyostotic fibrous dysplasia, together with cutaneous hyperpigmentation, and precocious puberty in females. As in this case, there was a tendency to unilaterality, the skin and bone manifestations both being more marked on the same side. No endocrine dysfunction was observed in the few male cases reported by the above authors. However, polyostotic fibrous dysplasia was recently described in a male sixteen years of age with feminine secondary sexual characteristies.[13] A large hemorrhagic cyst of the skull was an atypical finding in this case. Albright, Scoville, and Sulkowitch[3] suggested that the unilaterality in these cases might best be explained on the basis of a disseminated neurological lesion, to which the endocrine dysfunction is secondary. No evidence was found in the present case for either endocrine or neurological disturbance.

The diagnosis of multiple congenital arteriovenous aneurysms in the left upper extremity, with the strong probability of similar communications involving the left femoral artery and vein, was substantiated by the following findings:

1. Thrills and bruits over the left upper extremity and left femoral artery.
2. Oxygen saturation of 90 per cent. in venous blood from the left forearm.
3. Higher skin-temperature readings over the left upper extremity.
4. Greater amplitude of oscillometric readings over the left arm, forearm, and thigh.
5. Bradycardiac phenomenon.
6. Cardiac enlargement.

This appears to be the first reported instance of polyostotic fibrous dysplasia with such a complication. Although hemihypertrophy of extremities may occur with arteriovenous fistulae, the latter probably played a minor rôle in producing the extreme degree of involvement of the left upper extremity and femur. The association of this congenital vascular anomaly with a disorder of bone, likewise a mesodermal derivative, strongly suggests that the two may have some congenital factor in common. This supports the view of Lichtenstein that polyostotic fibrous dysplasia results from a congenital disorder of the bone-forming mesenchyma. The varied findings which have been associated with it in the reported cases may, for the present, we believe, logically be assumed to represent further manifestations of the defect in the germ plasm responsible for the bone pathology.

SUMMARY

1. A case of polyostotic fibrous dysplasia with cutaneous pigmentation in a male is presented, together with the diagnostic criteria of the disorder.

2. The presence of arteriovenous communications on the side of the predominant bone involvement is advanced as additional evidence for a congenital etiology of the condition.

3. Recognition of the nature of this osseous dystrophy may prevent unnecessary surgery and possible sacrifice of normal parathyroid glands.

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A STUDY OF PARALYTIC SCOLIOSIS BASED ON FIVE HUNDRED CASES OF POLIOMYELITIS * †

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The purpose of this report is to review the findings in a series of 150 patients with paralytic scoliosis, and to analyze some of the mechanical factors involved in the development and treatment of these cases. An attempt has been made to determine the reasons for the development of the curvature, and its possible prevention and treatment. The follow-up period has extended back twenty years with a rather even distribution of cases each year except 1937, in which there was a poliomyelitis epidemic within the state.

GENERAL CONSIDERATIONS

Scoliosis has developed in 150 patients, or 30 per cent., of the 500 cases of poliomyelitis studied to date. This seems an unusually high percentage, and the authors hope to show some of the reasons for it, keeping in mind that a revision of this percentage may have to be made as the study continues. A Scoliosis Clinic at the Crippled Children's Hospital has been established, and all cases of lateral curvature of the spine have been registered. Sixty-two per cent. of them have been caused by

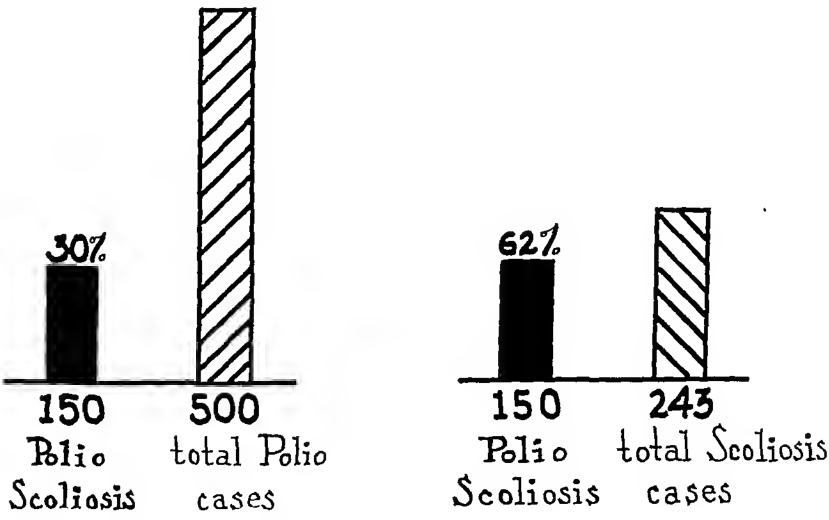

FIG. 1

* Read at the Annual Meeting of the American Orthopaedic Association, Kansas City, Missouri, May 7, 1940.

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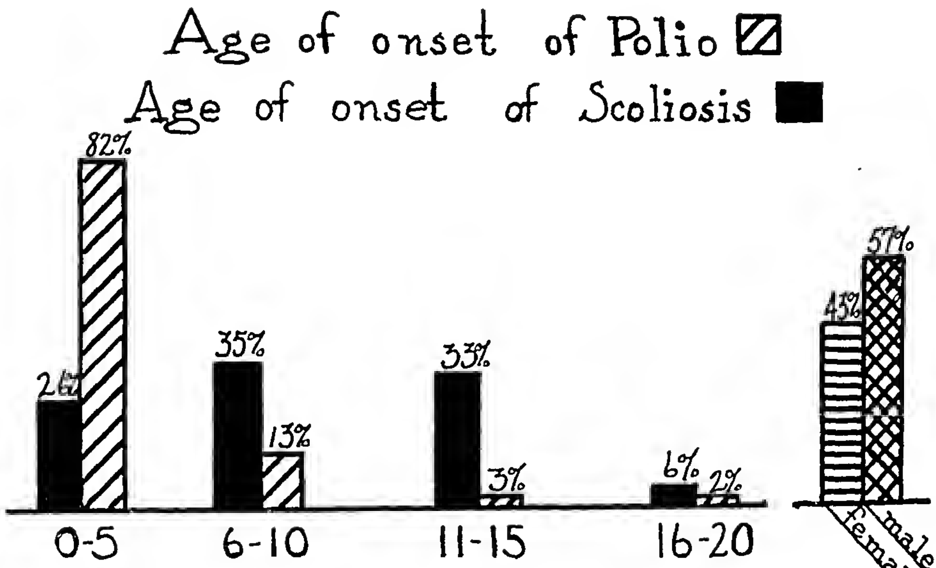

FIG. 2

infantile paralysis (Fig. 1). Figure 2 shows the age of onset in all the poliomyelitis cases, and the approximate age of the patient when the scoliosis developed. There was a latent period, before the development of the curvature, which ranged from a few months to twelve years, but in this delayed-development group the patients presented little if any trunk involvement. Here it is felt that other mechanical factors such as weak hip muscles or unequal leg length played the more important part.

It has been said that scoliosis will not progress after growth ceases; this the authors have found to be true of the idiopathic type, but not true of all the paralytic cases in this series. Four cases were found in which the curvature developed after the age of sixteen, though repeated measurements showed no further growth. In one a severe scoliosis developed at about twenty years of age. In a review of 500 poliomyelitis cases, forty-five, or 13.5 per cent., had some upper-extremity paralysis, and in thirty-six, or 81 per cent., of these scoliosis developed. Four hundred and thirty-five patients, or 87 per cent., had some lower-extremity involvement, and in ninety-six, or 22 per cent., of these scoliosis developed. One hundred and fifty-seven, or 31 per cent., of these patients had trunk involvement, of whom 135, or 86 per cent., showed a scoliosis. Seven per cent. of the patients with structural scoliosis had extremity involvement without any demonstrable trunk paralysis. There were twenty-one cases with paralytic involvement of the trunk, but without scoliosis two years or more after the attack of poliomyelitis. This group is particularly interesting and will be dealt with in more detail later. In the total cases examined, only seventeen patients have had a complete recovery from their muscle paralysis, and of these the extremities were involved in thirteen and the trunk in four.

Very few of the patients with paralytic scoliosis had adequate early treatment, as 69 per cent. had no recumbency or a period of less than

six weeks after the onset of the disease Twelve per cent. were recumbent from six to twelve weeks; 14 per cent., from three to six months; and only 5 per cent., six months or more. Back supports were employed in only one out of every five, and 59 per cent. had no support at any time. Sixteen per cent. had support before the spinal deformity was detected, and twenty-five per cent. received support only after the scoliosis was obvious. It is of interest that severe deformity developed in many of the latter cases. It is the authors' belief that efficient support of a progressive scoliosis is very difficult, and with the high thoracic curve it is virtually impossible. With a lumbar curve, the spine may be supported in a plaster or celluloid jacket, or occasionally with a crutch type of brace.

Thirty patients had been fitted with canvas corsets, usually before becoming ambulatory, and standing roentgenograms, taken with and without the corset, showed these supports were usually ineffective. Various types of back braces were employed, but it was not infrequently found that the curvature extended above the edge of the brace so that the lack of support was obvious. In most of the cases with progressive curves, the inadequacy of any type of supportive treatment could be demonstrated by the standing and supine roentgenograms. The accordionlike deformity which developed in many of these patients was remarkable, and head traction often demonstrated an amazing degree of correction. Figures 3-A and 3-B show a child who was easily lengthened eight inches by head traction, being manually lifted.

While it is the authors' general impression that scoliosis develops more rapidly during active growth periods, other factors—such as a short

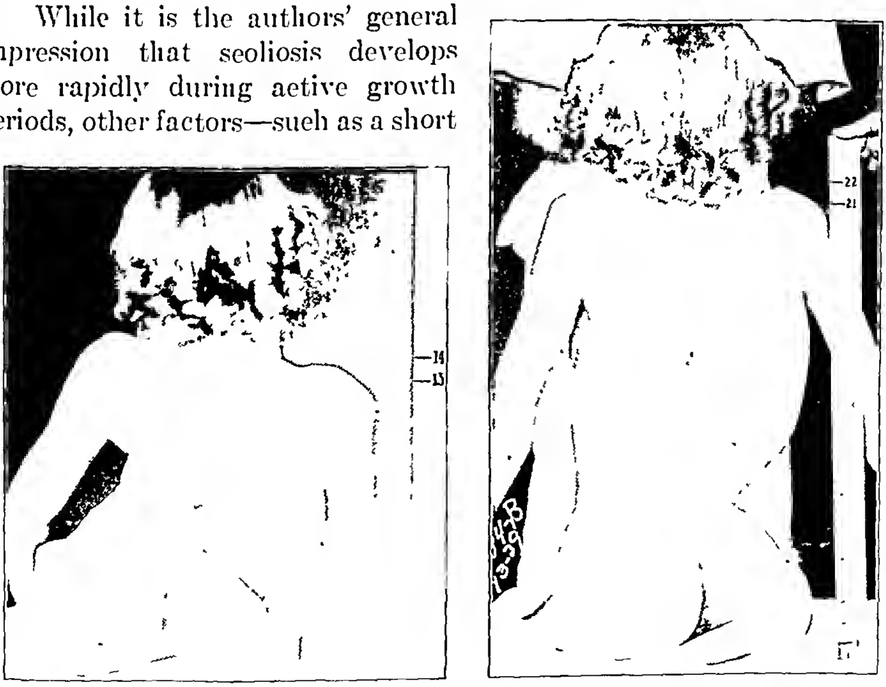

FIG. 3-A FIG. 3-B

Photographs of patient, aged eight, in sitting position. Note the accordionlike characteristic as she is lifted manually by the chin and occiput.

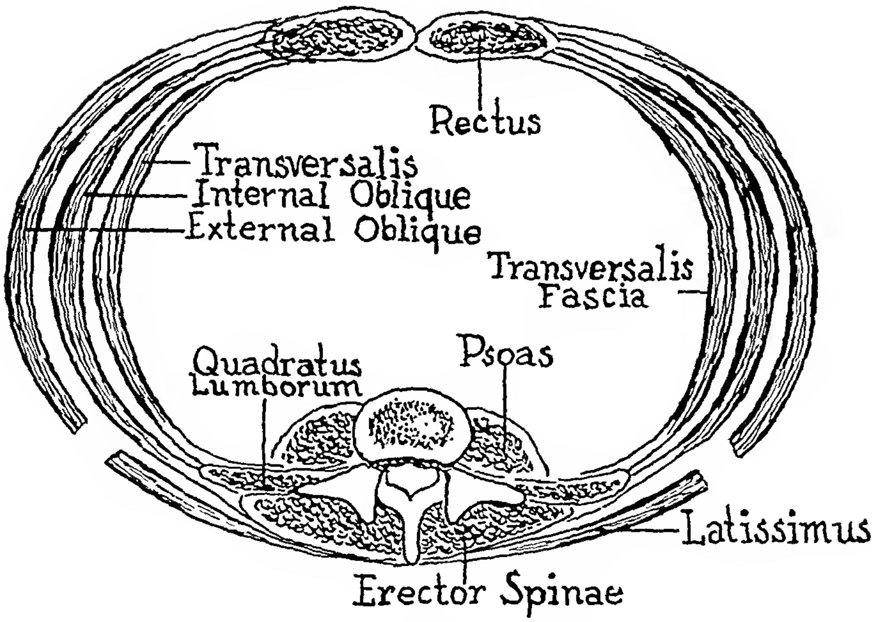

FIG. 4

NOTE: The names of the muscles shown on this drawing do not in all cases coincide with the names generally used in *The Journal:*
Rectus = rectus abdominis;
Transversalis = transversus abdominis;
Internal oblique = obliquus internus abdominis;
External oblique = obliquus externus abdominis;
Psoas = psoas major;
Erector spinae = sacrospinalis.

period of recumbency following the disease, the build of the patient, and the severity of the original paralysis—will also influence the degree of the curve. Severe curves developed in all of the cases with marked asymmetrical paralysis, though in 14 per cent. progression was arrested and corrected by turnbuckle jacket and fusion treatment.

The postpoliomyelitis scoliosis developing in a young child is usually a progressive affair. Therefore, efforts should be directed toward prevention of the scoliosis as far as possible. The authors believe that any patient with a trunk paralysis should have a minimum period of six months in absolute recumbency. Physiotherapy may be instituted after the muscle tenderness has subsided and, if intelligently used, will undoubtedly aid, but if not intelligently used it may strengthen the strong muscle groups and not affect those which are paralyzed.

PHYSIOLOGICAL CONSIDERATIONS

As pointed out by Jones and Lovett many years ago, lateral flexion and rotation of the spine do not occur as separate movements; so, when the spine is bent laterally, a certain amount of rotation automatically occurs, and the bodies of the vertebrae are rotated toward the convexity of the curve.

The majority of the lateral curvatures begin at the junction of the thoracic and lumbar regions. The thoracic region of the spine normally has very little motion in any direction, not only because the thoracic cage

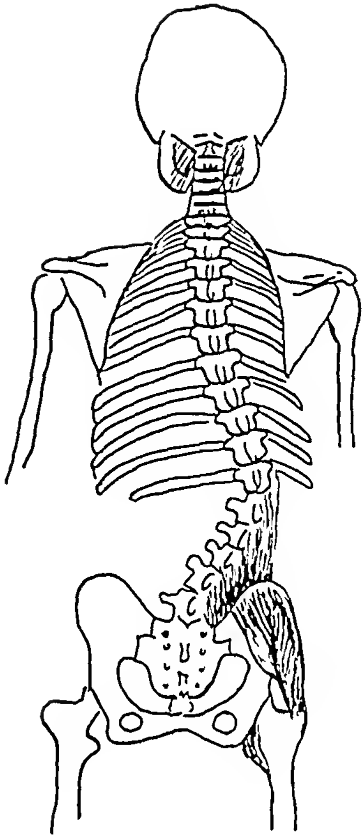

Fig. 5

Paralysis of the iliopsoas occurred in 103 cases, and of the gluteus medius in 120 cases.

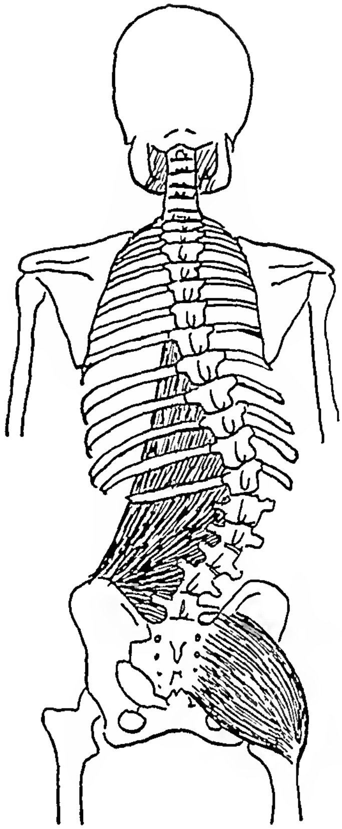

Fig. 6

Paralysis of the obliqui abdominis occurred in 126 cases, and of the gluteus maximus in eighty-five cases.

is attached in this region, but also because of the conformation of the individual vertebrae in this portion of the spine and the absence of any muscles permitting flexion in the thoracic cage. Posteriorly the sacrospinalis group of muscles produce extension throughout the entire spine. In the lumbar region the quadratus lumborum, psoas major and minor, and the abdominal muscles play a very important part in producing paralytic scoliosis (Fig. 4). Mackenzie has pointed out that the abdominal muscles do not produce flexion or rotation of the trunk, but with this the authors do not agree. These muscles are, however, primarily for support of the abdominal wall and for use in the physiological processes of respiration. Contraction of the rectus abdominis, Mackenzie points out, does not cause physiological relaxation of the sacrospinalis group of muscles. These abdominal muscles give increased strength to visceral support and are useful as the antagonists of the diaphragm muscles. The authors are convinced that the principal muscles flexing the spine are the rectus abdominis, internal and external obliques, as well as the iliopsoas and quadratus lumborum. If the muscles producing the patient's spinal move-

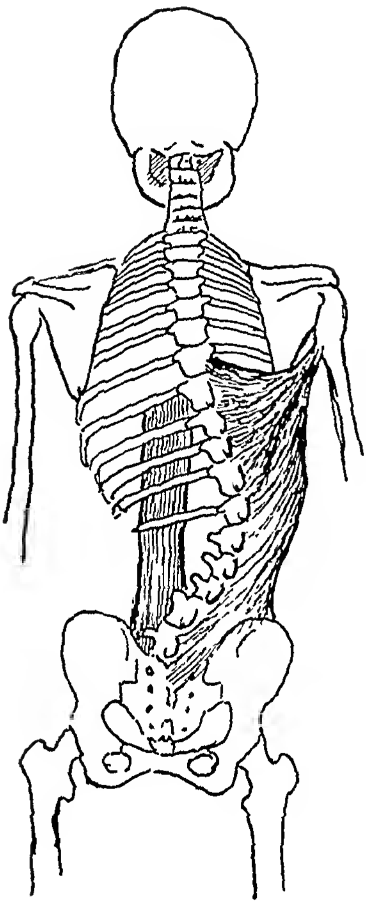

FIG. 7
Paralysis of the rectus abdominis occurred in seventy-four cases, and of the latissimus dorsi in sixty-three cases.

ments act normally, there is a normal range of motion. If the flexing muscles can act only unilaterally they will, with the exception of the iliopsoas, produce a lateral deviation and rotation of the spine with the concavity toward the strong side. The iliopsoas will produce a convexity toward the strong side. In this study lumbar paralytic scoliosis with abdominal-muscle involvement alone has been found, although occasionally the same curve has developed without abdominal-muscle paralysis. It would be particularly interesting to know whether the type or degree of curve that will routinely develop from a spinal or abdominal paralysis can be predicted. It may be of some value to compare the spinal potentialities for movement with those found in an extremity. In the extremities various movements are produced by one set of flexors, rotators, and extensors, but in the spine these movements are produced by two sacrospinalis groups, two iliopsoas muscles, two quadratus lumborum muscles, etc.,—one set on each side of the body. This construction of two groups of flexors and two groups of extensors and rotators greatly increases the complexity of the whole scoliosis problem. The deformity, therefore, is always dependent upon the muscle pulls plus the individual bone conformation of the particular vertebrae involved, and *these factors are present even though the paralytic patient is recumbent.* The authors have seen curves produced through this muscle imbalance even though the patient was recumbent and properly splinted. Added to this is the great factor of gravity whenever the patient resumes the upright position. Therefore, deformity is produced by the pull of the stronger opposing group on one side or other of the body plus gravity. Steindler states that where the great rotators of the spine are lacking, the curvature may develop during recumbency, and he believes the external oblique is one of the most important rotators. The abdominal oblique muscles are the stabilizers of the rib cage, which enable it to swing laterally whenever the arm and shoulder girdle movements and the leg and pelvic movements produce an asymmetrical pull, and this pull gives rise to a rotary spinal deviation. The pull in one direction of the serratus posterior inferior, which is the chief opponent of the abdominal oblique and opposite transversalis colli, may be the stabilizing influence against this side twisting.

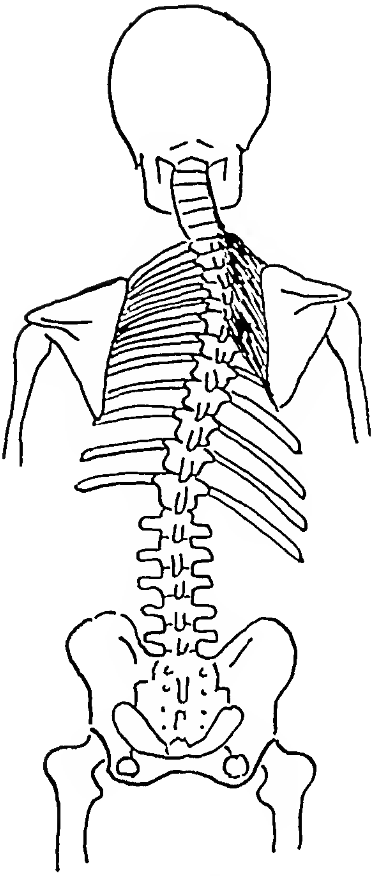

FIG. 8
The rhomboids were paralyzed in forty-two cases.

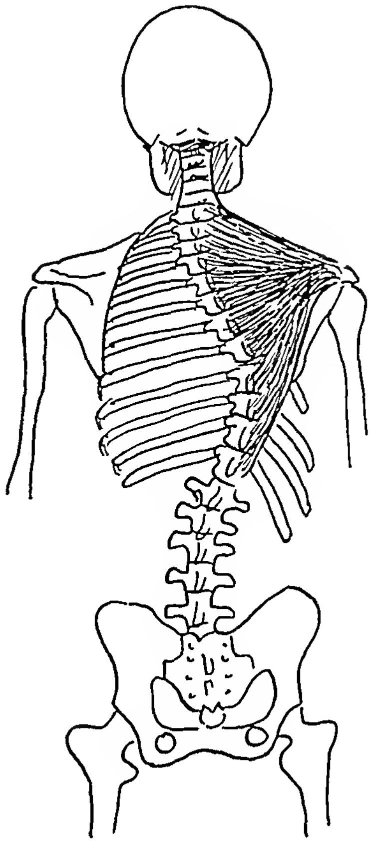

FIG. 9
The trapezius was paralyzed in twenty-eight cases.

MUSCLE GROUP INVOLVEMENT

Mayer made the observation some years ago that a fixed pelvic obliquity may be caused by contracture of the spinal muscles, of the abductor or adductor muscles about the hip, or by a combination of these, and Irwin has recently written on this same subject. Certain cases of pelvic obliquity, arising from contracture of the abductor group of muscles of the hip, with a distinct lowering of the pelvic crest and subsequent curvature of the spine have been noted in this study. This spinal curvature becomes obvious when the limbs are placed parallel,—the attitude assumed in weight-bearing. Only two cases have been found presenting fixed pelvic obliquity from this cause, which is somewhat at variance with the findings of Mayer and his associates. The authors are inclined to think this adductor contraction is frequently secondary, rather than primary, in cases of paralytic curvatures of the spine. They have attempted to classify the development of the paralytic progressive curve in relation to the muscle pull, and feel that the stronger muscles always tend to produce deformity, a fact not so well recognized in spinal deformity as in the paralytic deformity of the extremities. In addition to the pull of the asymmetrical

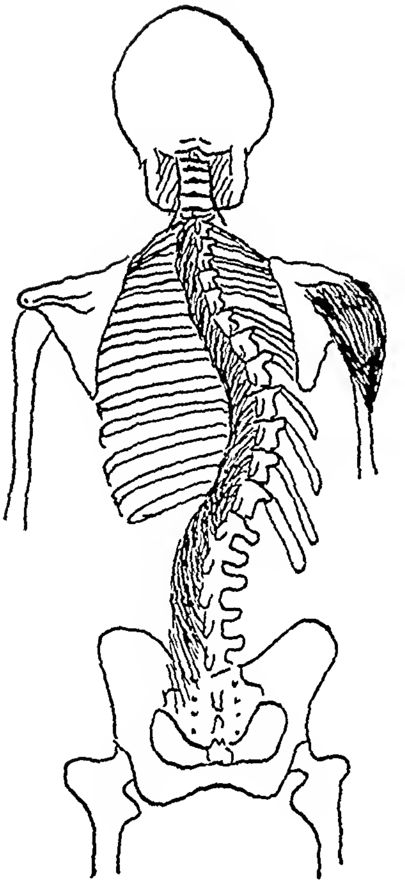

FIG. 10

The curve was toward the sound side in twenty-seven cases of paralysis of the sacrospinalis, and in twenty-three of the forty-five cases of paralysis of the deltoids.

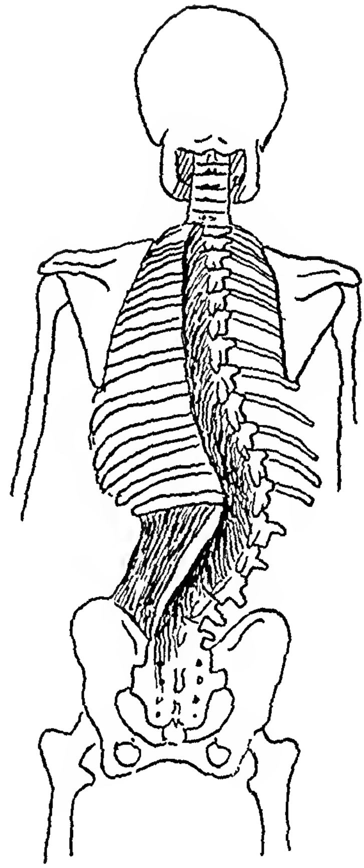

FIG. 11

The muscle pull was asymmetrical in nineteen of the cases of paralysis of the sacrospinalis, and in twenty-eight of the forty cases of paralysis of the quadratus lumborum.

muscle forces, the uncomplicated inequality of leg length is sometimes sufficient to initiate the process. Unequal leg lengths was felt to be the primary factor in twenty-two cases in this series.

The cases have been divided into two groups: (A) having the convexity of the curve toward the stronger muscle groups, and (B) having the concavity of the curve toward the stronger muscle groups.

In Group A unequal pull of the iliopsoas was present in twenty-nine of 103 cases, and as far as could be determined was the principal factor in producing the curve (Fig. 5). The same type of curve was found in fourteen patients of 120 with gluteus medius paralysis, and in eleven patients out of eighty-five with gluteus maximus paralysis (Fig. 6). Convexity toward the sound side may result from paralysis of the latissimus dorsi and this spinal deformity was found in thirty-four of a total of sixty-three paralyzed muscles (Fig. 7). This apparently is a very important type of paralysis, and in six cases the latissimus dorsi appeared to be wholly responsible for the development of the curvature. A similar curve was

found in rhomboid (Fig. 8) and trapezius (Fig. 9) paralysis,—that is, a pull toward the sound side in thirty-six of a total of forty-two affected rhomboids and in the twenty-eight paralyzed trapezii. Deltoid paralysis (Fig. 10) gave rise to a curve toward the sound side in twenty-three of forty-five cases of paralyzed deltoids.

Group B. Lowman has repeatedly emphasized the importance of asymmetrical abdominal-muscle paralysis. Thirty-one cases in this series presented the concavity of the curve toward the side of the strong abdominal muscles. In this abdominal group there were a total of 200 paralyzed muscles with 126 involving the obliques and seventy-four the recti (Fig. 7). A curvature with the concavity toward the sound side was noted in the cases of paralysis of the sacrospinolis, which was a very important factor in the development of many of the dorsal curves. The muscle pull was asymmetrical in nineteen cases of the forty-six with the sacrospinalis muscles involved and in twenty-eight of forty cases of paralyzed quadratus lumborum muscles; the concavity was always toward the sound side (Fig. 11). The other twelve patients presented symmetrical paralysis of the quadratus lumborum.

TYPES OF CURVES IN PARALYTIC SCOLIOSIS

In this study the curves produced have been divided into total and combined curves. The total curve of the long thoracolumbar type was found in seventeen cases. In the combined group, with primary and secondary curves, there were 133 cases. In this study of paralytic scoliosis 110 patients returned for roentgenograms, taken with the patient both supine and standing, which have been carefully reviewed and correlated with the muscle paralysis.

The primary curve in this combined type can be divided into three classes: the thoracic, thoracolumbar, and lumbar. There were sixty-three patients in the thoracic group. These curves have been divided roughly into those extending from the first to the ninth, from the third to the eighth, and from the fifth to the twelfth thoracic vertebrae, and an attempt has been made to analyze each type for the muscle pull or pulls producing it. In the thoracic-curve group the scoliosis is apparently produced by the upper extremity and back paralysis. Of these sixty-three cases, thirty-three had the convexity to the right and thirty to the left, showing that the muscle paralysis is about equally divided on the two sides of the body. In the second class of combined curves, the mid or thoracolumbar curve, extending from approximately the sixth to the third lumbar vertebrae, there were twenty-nine cases. These apparently were produced primarily by a combination of abdominal and upper or lower extremity involvement, especially the latissimus dorsi. In the lumbar or lower type of curve, extending roughly from the tenth thoracic to the fourth lumbar vertebrae there were forty-one cases. These were primarily produced by paralysis of the latissimus dorsi, abdominal muscles, iliopsoas, or the abductor muscles about the hips. Beevor's sign

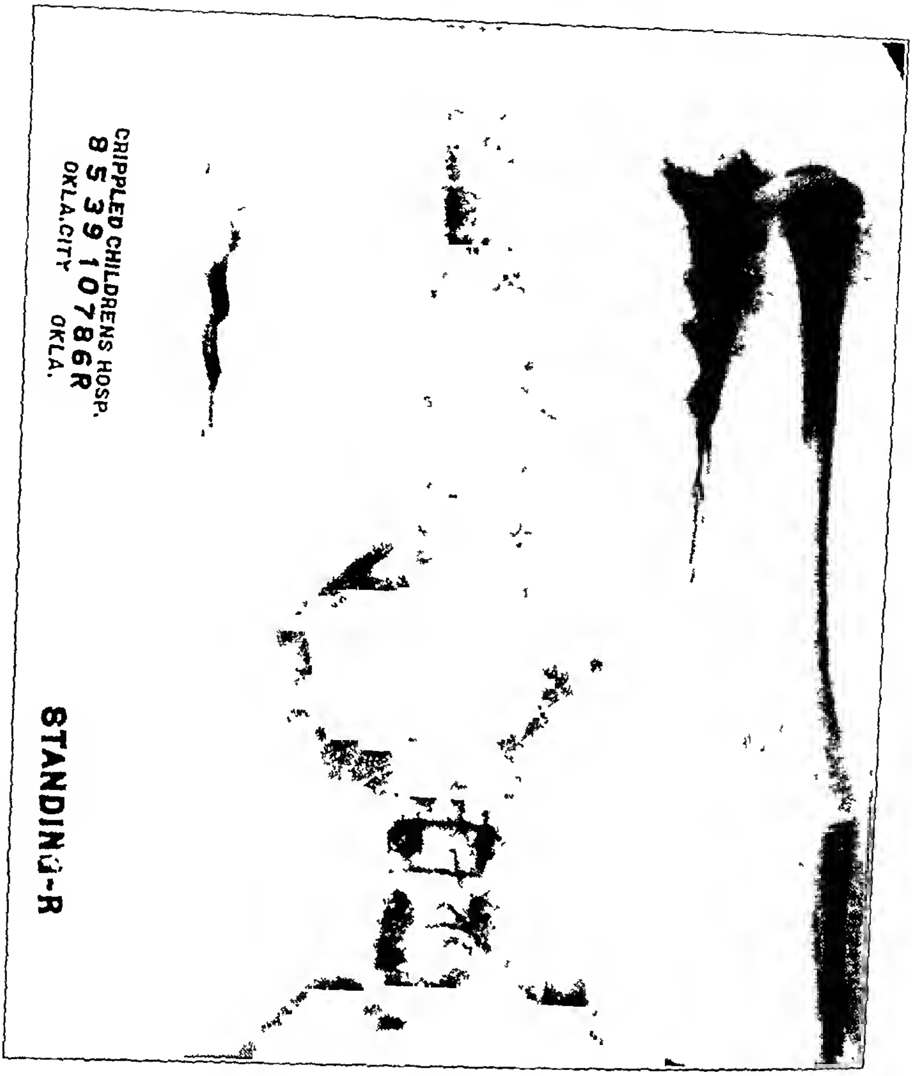

Fig. 12-A

Roentgenogram of patient with complete abdominal paralysis and a marked lordosis, but no scoliosis Fig. 12-A: Anteroposterior view of patient standing.

is a valuable one,—that is, there is normally no movement of the umbilicus on raising the head from the supine position, but with paralyzed or weakened abdominals the umbilicus shifts its position as tension is placed upon these muscles. In this series of cases, Beevor's sign was unfortunately not routinely observed, but every one of the nineteen patients in whom it was found presented abdominal weakness or paralysis.

Occasionally a double primary curve may result from a rather extensive paralysis. One such patient had adequate muscle paralysis to explain the two primary curves, and in addition had the two usual compensatory curves,—a total of four instead of the usual three curves.

TRUNK PARALYSIS WITHOUT SCOLIOSIS

In the total series of cases, twenty-one patients have not developed scoliosis and yet present definite trunk paralysis. These are not included

Fig. 12-B

Lateral view of same patient in supine position.

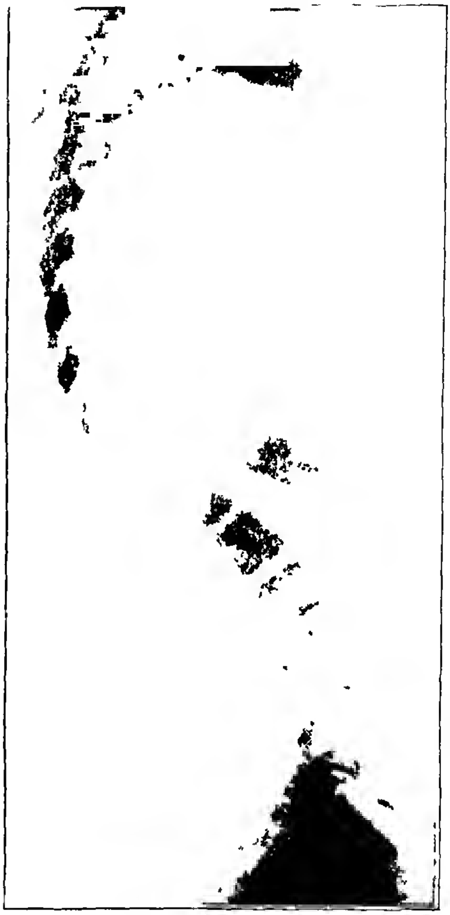

Fig. 12-C

Lateral view of patient standing.

in the 150 cases of paralytic scoliosis, but constitute a very interesting and informative group. Without exception the trunk paralysis in each of these cases was almost completely symmetrical. In this group patients were found with complete abdominal paralysis and a marked lordosis without lateral curvature (Figs. 12-A, 12-B, and 12-C). Conversely, in over 500 unselected cases of poliomyelitis, there was not a single case with marked asymmetrical trunk paralysis in which a scoliosis did not develop. In this small group of twenty-one cases, there were fourteen patients who had been followed for two years or more after the attack of poliomyelitis, but had not developed a curve; so the future development of scoliosis in these cases may be regarded as possible though improbable (Fig. 13). If the trunk can be balanced by the remaining symmetrical groups, it brings up the question of utilizing this principle in treating cases of muscle imbalance by methods not ordinarily used. Correction of paralytic scoliosis has not been treated as effectively as paralytic deformities elsewhere. In the foot, for example, muscles are transplanted or sectioned in combina-

FOURTEEN CASES

Trunk Paralysis without Scoliosis

Left — Right

14	13	12	11	10	9	8	7	6	5	4	3	2	1	case number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
13	30	5	4	4	7	3	4	4	3	5	20	6	7	age	7	6	20	5	3	4	4	3	7	4	4	5	30	13
11	6	2	2	2	2	2m	1½	2	1	3	18	4	4	onset age	4	4	18	3	1	2	1½	2m	2	2	2	2	6	11
P	FG	GF	N	N	N	GN	N	N	N	N	P	N	F	Erector Spinae	F	N	O	N	N	N	GN	GN	G	N	N	GF	FG	P
P	O	GF	N	N	N	GN	N	N	P	N	P	F	GN	Quadratus Lumborum	GN	N	O	N	P	N	GN	GN	GN	N	GN	GF	O	P
F	N	GF	N	N	N	GN	N	N	N	N	G	N	G	Latissimus Dorsi	G	G	N	N	N	N	N	GN	N	N	G	GF	N	F
G	FG	GF	GN	N	N	GN	N	N	N	N	N	N	G	Rhomboids	G	G	N	N	N	N	N	GN	N	N	GN	GF	F	G
T	FG	GF	G	F	N	G	G	N	G	FG	O	N	N	Rectus Abdominus (upper)	N	G	O	FG	G	N	G	G	N	N	F	GF	FG	O
P	FG	GF	G	G	FG	G	N	N	G	PF	O	N	N	Rectus Abdominus (lower)	N	N	O	PF	G	N	N	G	N	G	F	GF	FG	P
O	N	GF	FG	N	N	F	G	N	T	G	O	G	N	Oblique Abdominal (upper)	N	G	O	G	P	N	G	G	N	F	PF	GF	N	P
P	N	GF	FG	N	N	F	P	FG	P	G	O	F	N	Oblique Abdominal (lower)	N	G	O	G	P	FG	P	P	FG	F	FG	GF	N	P
T	G	N	F	N	O	O	F	FG	O	N	O	F	N	Iliopsoas	N	G	T	FG	O	O	FG	N	G	N	F	N	G	P
P	O	G	FG	N	P	O	PF	P	O	N	T	P	N	Gluteus Medius	N	F	P	FG	O	F	G	N	PF	O	FG	G	O	P
G	N	O	N	N	N	N	N	N	N	N	G	N	O	Deltoid	F	N	T	N	N	O	N	N	N	N	N	G	N	T
F	N	O	N	N	N	N	N	N	N	N	N	N	N	Trapezius	N	N	G	N	N	N	N	N	N	N	N	G	N	F

N=Normal G=Good F=Fair P=Poor T=Trace O=Absent

FIG. 13

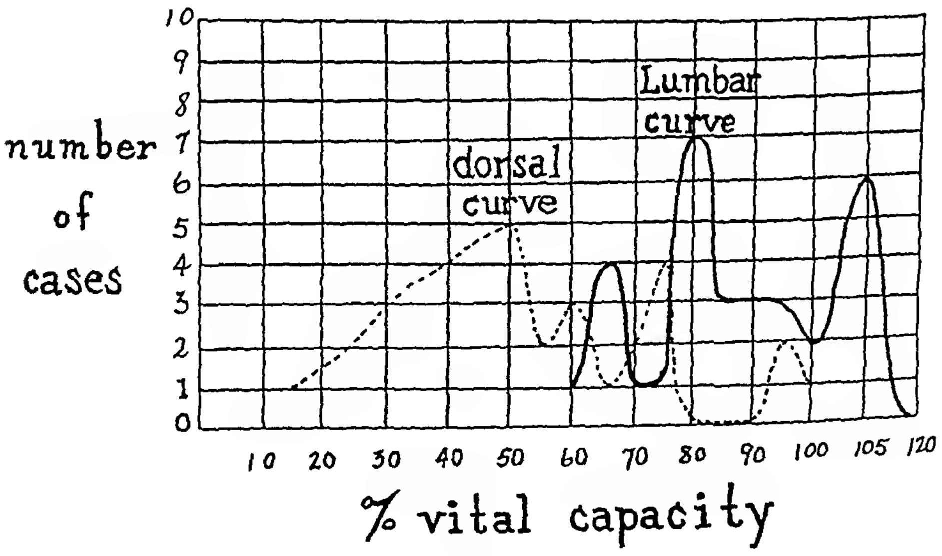

FIG. 14

tion with joint fusion to prevent recurrence of the deformity. May deformities which are produced by the vicious pull of asymmetrical muscle groups be corrected through myotomies, transplantations, etc., rather than by simply fusing the spine?

OBESITY

About 30 per cent. of the total number of patients became more or less obese following their poliomyelitis. The increase in weight was frequently quite sudden and usually began about four months after the onset of the disease. A number of our patients have had a low basal

metabolic rate, and an endocrine disturbance is probably present. This added weight is naturally a disadvantage to any patient with weak trunk muscles, and is an added burden on the spine.

VITAL CAPACITY

In sixty-two of the patients with paralytic scoliosis, vital-capacity readings were obtained, using the DuBois method with a Collins spirometer, and it was found that those with scoliosis of the thoracic region produced the lowest vital-capacity reading, while those with curves in the lumbar region consistently had a higher reading. The vital capacity of the sixty-two patients varied from 15 per cent. to 111 per cent. with an average in the thoracic region of 56 per cent. and in the lumbar region of 88 per cent. (Fig. 14). Those patients in whom the curve involved the rib cage presented compression and displacement of the lungs and heart, often to an alarming degree. The patients with an extremely low vital capacity are naturally an easy prey to upper respiratory and lung infections and many of them are obviously poor surgical risks. The use of empyema blow bottles and toy balloons into which the patients blew ten or twelve times daily, frequently caused marked improvement in the vital-capacity reading. In a number of cases these simple methods more than doubled the vital-capacity reading in from one to three months.

METHODS OF TREATMENT

Every effort should be made to improve the general condition of these patients by a careful regimen of muscle training, sun baths, and chest-expansion exercises. Attention should also be paid to diet, either for increasing or reducing the weight of the patient. Several of these patients also had a preoperative course of glandular therapy to improve the lowered basal metabolism and lessen the tendency to obesity.

Lowman states that the loss of the integrity of the abdominal muscles is closely related to the development of paralytic scoliosis, and has suggested the use of fascial strips. The authors' observations have confirmed his findings that fascial strips give a feeling of security to the patient, and have a stabilizing effect upon the remaining trunk muscles and pelvis. The patients have expressed themselves as feeling much more comfortable, and by better balance they have been relieved of the feeling of "toppling over backwards". A fascial sling has also been used in a case with paralyzed rhomboids; the strips were extended from the spinous processes to the vertebral border of the scapula, but the authors' experience has been so limited that they cannot draw definite conclusions regarding its benefit. The stripping of muscles and fascia from the spinous processes and laminae has been reported, but the authors have had no personal experience with these procedures. As far as can be learned through personal communications, these results have been rather transitory.

When an optimum general condition has been reached and an evaluation of the muscle paralysis made, it can be assumed that the development

of a scoliosis will simply be a matter of time, if the paralysis is asymmetrical, but the opposite will be true if there is a fairly symmetrical involvement. This latter type of case should be studied very carefully for a long period of time for the possible development of asymmetry and a late scoliosis. Supine and standing roentgenograms are taken of all patients at three-month intervals. If there is a definite progression of the curve, fusion has been recommended as the only method that will effectively stop the progression. The younger the patient, the greater is the necessity

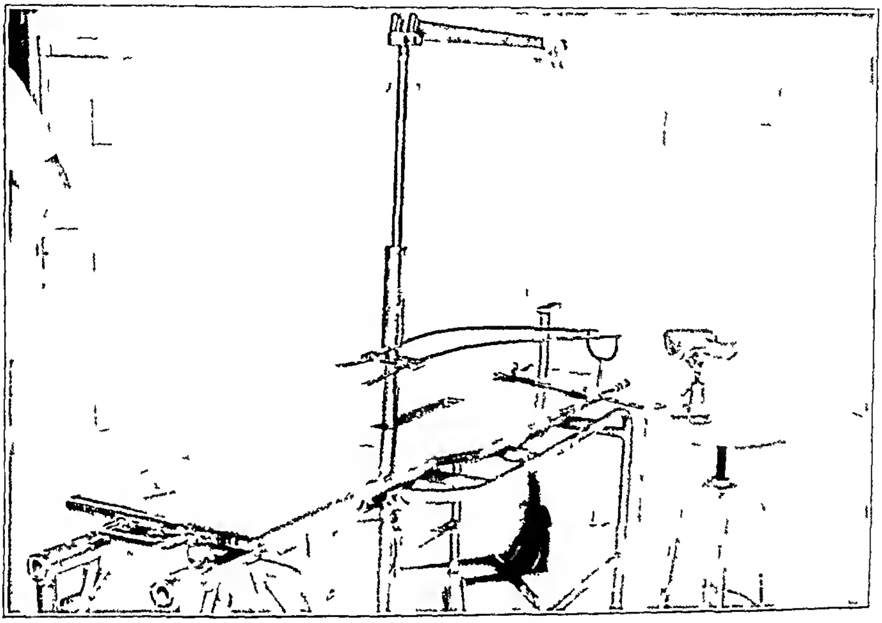

FIG 15

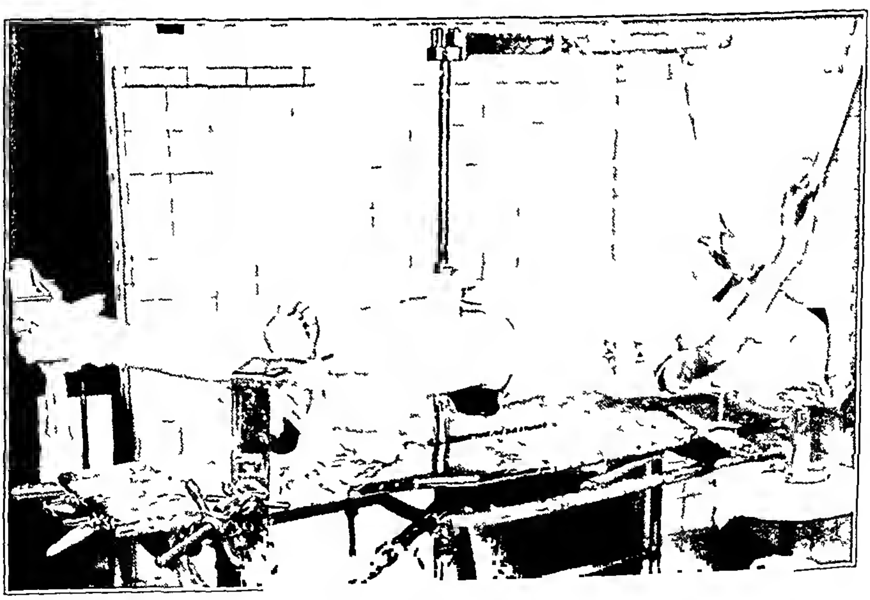

FIG 16

Application of plaster jacket with patient's trunk bent toward the concave side of the primary curve always straightens to some extent the secondary curve

for corrective jacket and fusion, provided the paralysis is grossly asymmetrical. If the patient is at the end of the growth period and roentgenograms show little or no mobility of the primary curve, fusion may not be necessary for the prevention of further deformity. However, other factors will influence the patient in the choice of a fusion operation,—such as appearance, balance, and stability, any of which may make fusion desirable.

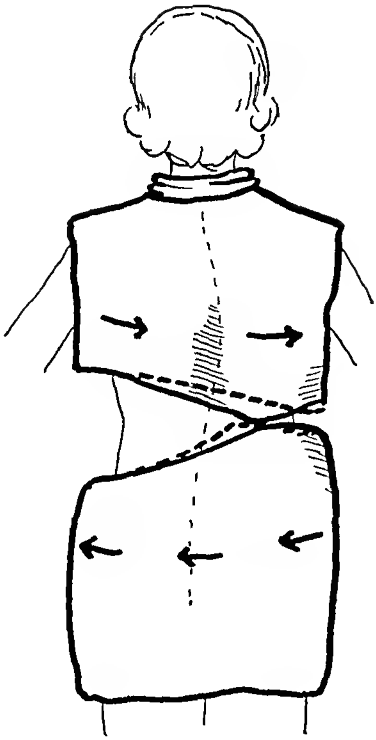

Fig. 17

Method employed for derotating the spine.

Only 14 per cent. of the patients have had fusion operations, but a great many more are being prepared for fusion because it is felt it offers the patient a great deal of benefit. The operative treatment of scoliosis depends upon the age, and the mobility and extent of the curve, as well as the general condition of the patient. The extent of the primary curve is calculated by the method of Risser and Ferguson, and the Risser type of jacket is usually employed for correction.

The jacket is applied with the patient's trunk bent toward the concave side of the primary curve, because in this way the secondary curves can be partially or completely straightened (Figs. 15 and 16). This also has the advantage of considerably derotating the spine because the primary curve apparently acts as a unit. After maximum correction has been obtained by the usual wedging method, another modification has been used. The hinges and turnbuckles are removed and by exercising great care not to lose lateral correction, the upper part of the jacket is rotated on the lower part so as to bring the shoulder on the convex side of the curve forward. (Fig. 17). Marked cosmetic improvement has resulted from this manœuvre, and the fusion operation has been thereby greatly simplified. The operation is performed through a window in the original plaster. Figure 18-A shows a roentgenogram of a child of eight, presenting a thoracolumbar type of curve straightened (Fig. 18-B) in the usual fashion, though moderate rotation can be noted. The spine was then derotated by bringing the right shoulder forward, and, as can be seen, complete derotation was obtained (Fig. 18-C).

Fusion was performed by a modified MacKenzie Forbes technique. Additional bone is usually used and may be taken from the tibia or ilium. In the mid-thoracic region a little more extensive dissection has been done, using the transverse processes and rib shavings as additional bone.

It has not been possible to derotate completely all the spine, so that

Fig. 18-B
Correction in turnbuckle type of jacket.

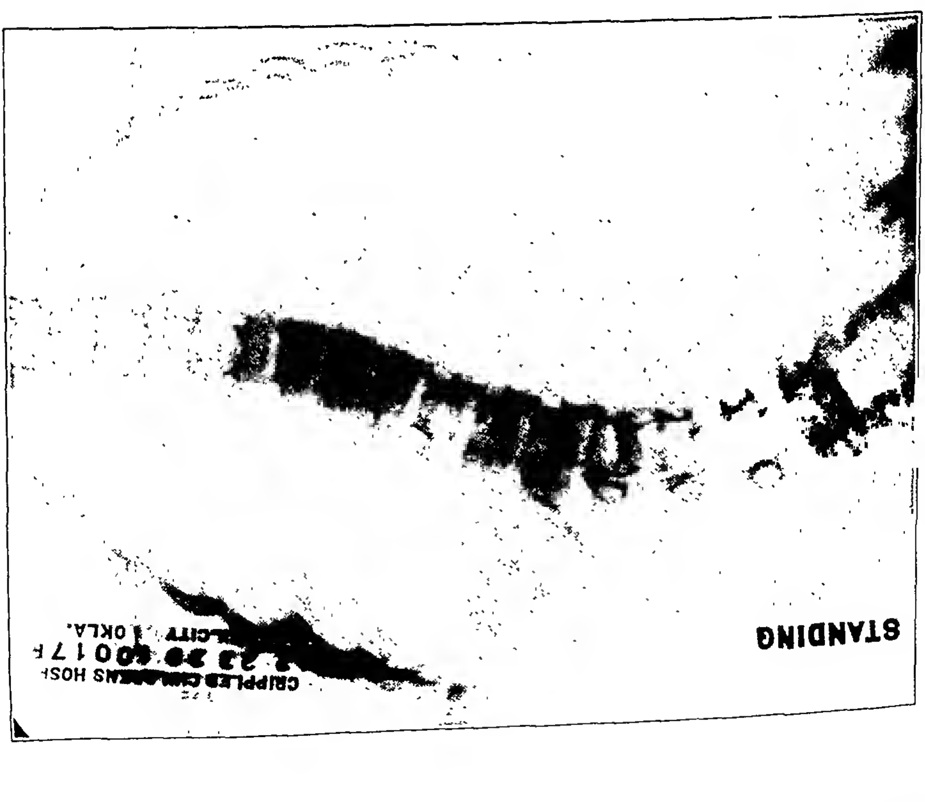

Fig. 18-A
Paralytic thoracolumbar type of curve.

some of the older, stiffer, more deformed patients may retain a fairly marked razor back after all possible correction. With this type of deformity some of the deformed ribs have occasionally been removed at the time of fusion and used as bone grafts. This method was described in 1927 by Armitage Whitman.

Pain resulted from impingement of the scapula on the deformed ribs in some of the older cases in whom fusion was not necessary. These cases were frequently benefited by rib resection. The vital capacity was not affected because apparently the lung on that side had been previously so compressed as to be of little functional value.

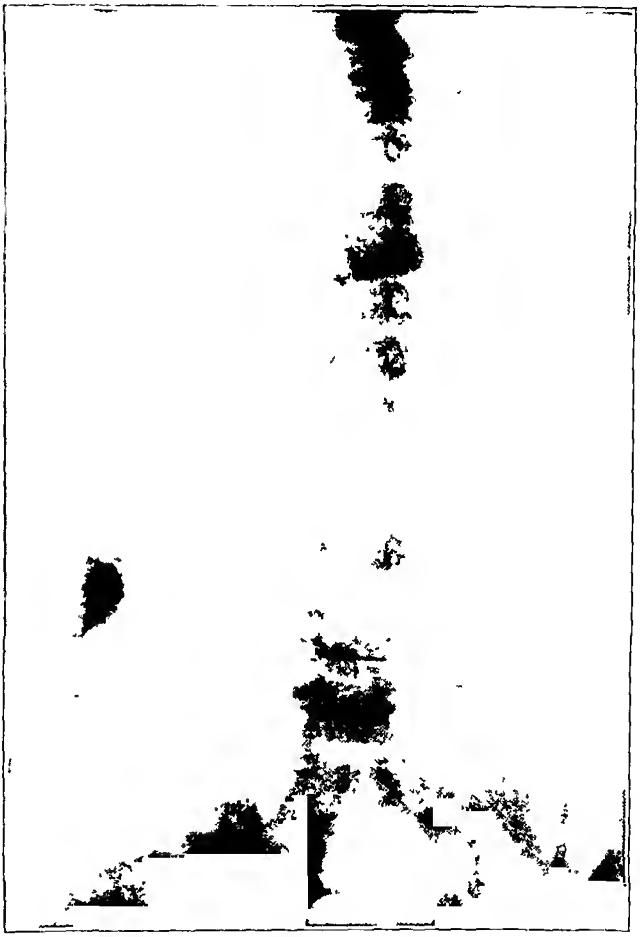

Fig. 18-C

Derotation obtained as noted in the text.

Because of the deforming effect of some of the active muscles in patients with asymmetrical scoliosis, the question has been raised as to whether or not some type of muscle operation would not offer an opportunity of lessening this vicious force. Using the foot as an example, it is known that, despite adequate and solid fusion, deformity will often recur in the growing child from the persistent unequal muscle pull. For this reason, the question is raised as to whether, in the young and adolescent children who will require fusion, it would not be wise intentionally to attempt some type of muscle sacrifice to balance the muscle pull.

Some mention may not be amiss regarding the anaesthesia employed with these patients who are so often poor surgical risks. The usual anaesthetic used is gas and oxygen or cyclopropane, but in a few patients presenting marked reduction of vital capacity a regional block, using one-half-per-cent. novocain, has been done. The authors have been much

pleased with the uneventful, easy convalescence following this anaesthetic. Coincident with the anaesthesia consideration, an adequate fluid balance is most necessary. This has been achieved by the preoperative, operative, and postoperative administration of saline, glucose, or whole blood. By careful attention to the patient's general condition, the risk of operation upon the badly deformed and paralyzed patient has been reduced to a minimum. In fifty-eight fusions done within the last two years by the authors there has been no mortality.

SUMMARY

Poliomyelitic involvement of the trunk muscles is a serious condition, and the patient may be completely incapacitated by the resulting severe deformities.

A scoliosis has developed in 150, or 30 per cent. of 500 chronic poliomyelitis patients consecutively examined.

The most important factors for the development of the curves have been a lack of early absolute recumbency, the presence of a marked asymmetrical muscle paralysis, and a lack of adequate supportive treatment from a conservative and operative standpoint.

Twenty-one additional patients were found with symmetrical trunk paralysis, in whom scoliosis has not developed. It is the authors' contention that a progressive scoliosis will usually not develop in cases with balanced trunk paralysis.

Seventeen patients, or 3.4 per cent. of the total cases, had a complete recovery from their known paralysis.

Various types of operative and non-operative treatment, with certain modifications, have been found useful in the fusion operation for paralytic scoliosis.

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SPONTANEOUS FRACTURE OF THE FEMORAL NECK FOLLOWING IRRADIATION

Report of a Case

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In the use of higher voltage irradiation for the treatment of malignancies, it has been possible to increase the roentgen-ray dosage to the deeper tissues. This more efficient therapy has resulted in an increased danger of damage to the adjacent normal tissues, among which is the skeletal system.

In 1926 Ewing, in a report on tissue reaction to radiation, described what he termed "radiation osteitis". The following year Baensch of Leipzig reported the first case of spontaneous fracture of the femoral neck following roentgen therapy for carcinoma of the cervix. The American literature contained no reference to this subject until 1936, when Dalby, Jacox, and Miller brought to light fourteen instances of spontaneous fracture of the femoral neck following irradiation for cancer of the female generative tract. Their study was continued by Peck[8] who added fourteen original cases in a report of twenty-eight spontaneous fractures of the neck of the femur, seen in a group of 1,026 patients treated with irradiation to the pelvis for malignancies in the pelvis. Like Baensch's original case, five of the twenty-eight patients had bilateral fractures. Recently Batt and Hampton have reported such a fracture in a sixty-year-old white male, who had received radiation following amputation of the penis for adenocarcinoma.

PATHOLOGY

Pathological studies have been carried out in six of the reported cases[2, 4, 6, 8]. In each instance the findings in the region of the fracture have been essentially the same,—namely, (a) obliteration and sclerosis of the blood vessels, (b) narrowing and irregularity of the trabeculae with an increase in the fatty marrow intermingled with necrotic debris, (c) absorption of bone and widening of the marrow spaces, (d) lack of new bone formation, and (e) no evidence of metastasis at the site of the fracture. Okrainetz and Biller demonstrated roentgenographically an area of bone absorption in the upper portion of the head of the right femur of a patient who had received roentgen therapy for a papillary adenocarcinoma of the ovary. The change appeared thirteen months following the therapy and eleven months preceding a spontaneous fracture of the neck of the femur. According to Peck[7] the initial changes usually develop in the superior

portion of the femoral head close to the neck. This observation has been confirmed in the reported case.

SIGNS AND SYMPTOMS

Philipp saw five patients in whom fractures of the femoral neck occurred following roentgen therapy. In none of his cases was there a history of injury. Of the fourteen patients reported by Dalby, Jacox, and Miller, there was no instance of a history of trauma. In every case pain antedated the diagnosis of fracture. The pain was generally located in the hip and radiated into the anterior thigh and knee. An average of seven months elapsed from the onset of hip symptoms until the fracture was demonstrated.

TREATMENT

Too few cases have been seen for a standard of treatment to be established. It has been pointed out that the production of callus is unlikely, but occasionally fibrous union develops sufficiently to permit a partial return of function. The fact that in a number of the reported cases the head has maintained its apparent normal calcium content indicates that the use of internal fixation might give a fair percentage of good end results. Badgley, after observing a patient for a year or more, performed Colonna's reconstruction operation. Too short a time had elapsed for a result to be given. In the case here reported, "blind nailing", before the fracture was completed, was suggested but not urged.

CASE REPORT

V. S. (A 16731). On March 14, 1939, a fifty-nine-year-old female was seen with a complaint of vaginal bleeding of five months' duration. Biopsy of the cervix showed a squamous-cell carcinoma. Roentgen therapy was given daily for a period of three weeks, 3,000 roentgen units were given over four pelvic fields, two anterior and two posterior, each 10 by 15 centimeters. No irradiation was given over lateral or side portals. The following formula was used: 400 kilovolts, 5 milliamperes, 70 centimeters anode skin distance, 4 millimeter copper filter. She tolerated the roentgen therapy well, and on May 18, 1939, was given 4,500 milligram hours of intra-uterine and intracervical radium, and 2,500 milligram hours of vaginal application.

In November, 1939, she had some transitory pain and stiffness in the right hip.

In March, 1940, she again developed pain in the right hip. On examination there was some tenderness about the hip joint. Motion was limited and accompanied by muscle spasm. There was no shortening and the bony landmarks were in normal relationship. An anteroposterior roentgenogram showed an incomplete fracture through the upper cortex of the subcapital region of the right femur (Fig. 1). A lateral roentgenogram did not demonstrate the defect. It was thought that the patient had an osteonecrosis of the neck of the femur, or possibly miliary metastases without typical roentgenographic changes. She decided against immediate "blind nailing" or other therapy, so was instructed to remain in bed for a period of two weeks and to report back to the clinic for roentgenographic examination at the end of four weeks. After a social-service follow-up she returned on May 20, 1940, fourteen months following the roentgen therapy and six months following her first symptoms of pain in the right hip.

Examination showed typical findings suggestive of a fracture of the right femoral neck. Roentgenograms showed a complete fracture through the subcapital region with

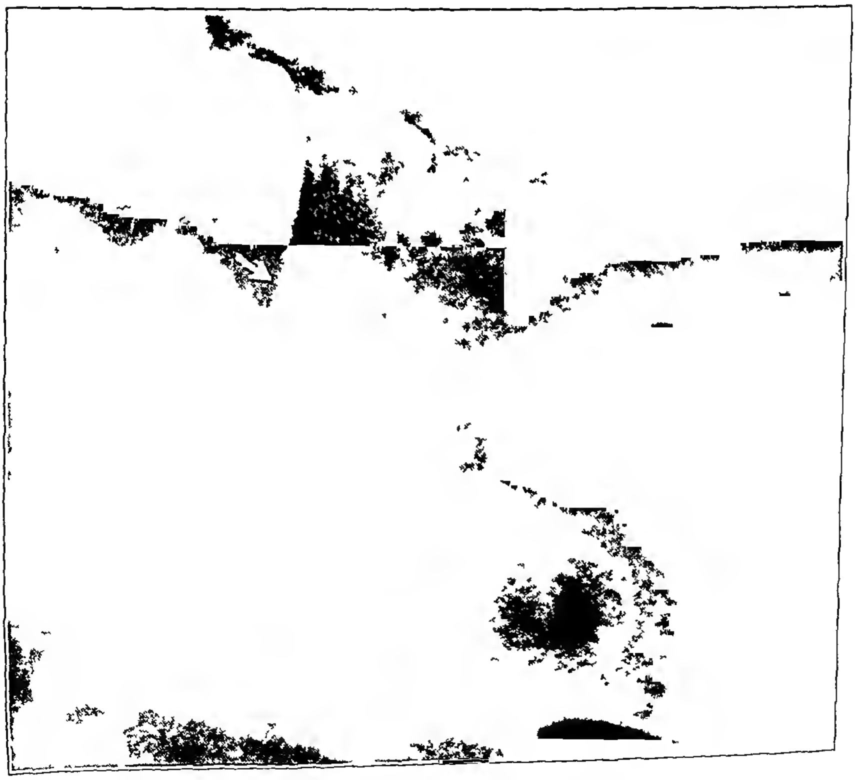

Fig. 1

Anteroposterior roentgenogram of the right hip taken on March 29, 1940. Arrow points out defect of incomplete fracture. Lateral roentgenogram of the neck of the femur did not demonstrate the fracture.

Fig. 2

Anteroposterior roentgenogram of the right hip taken on May 20, 1940. There is a complete fracture through the subcapital region of the neck of the femur with some absorption at the site of the fracture and slight upward displacement of the shaft.

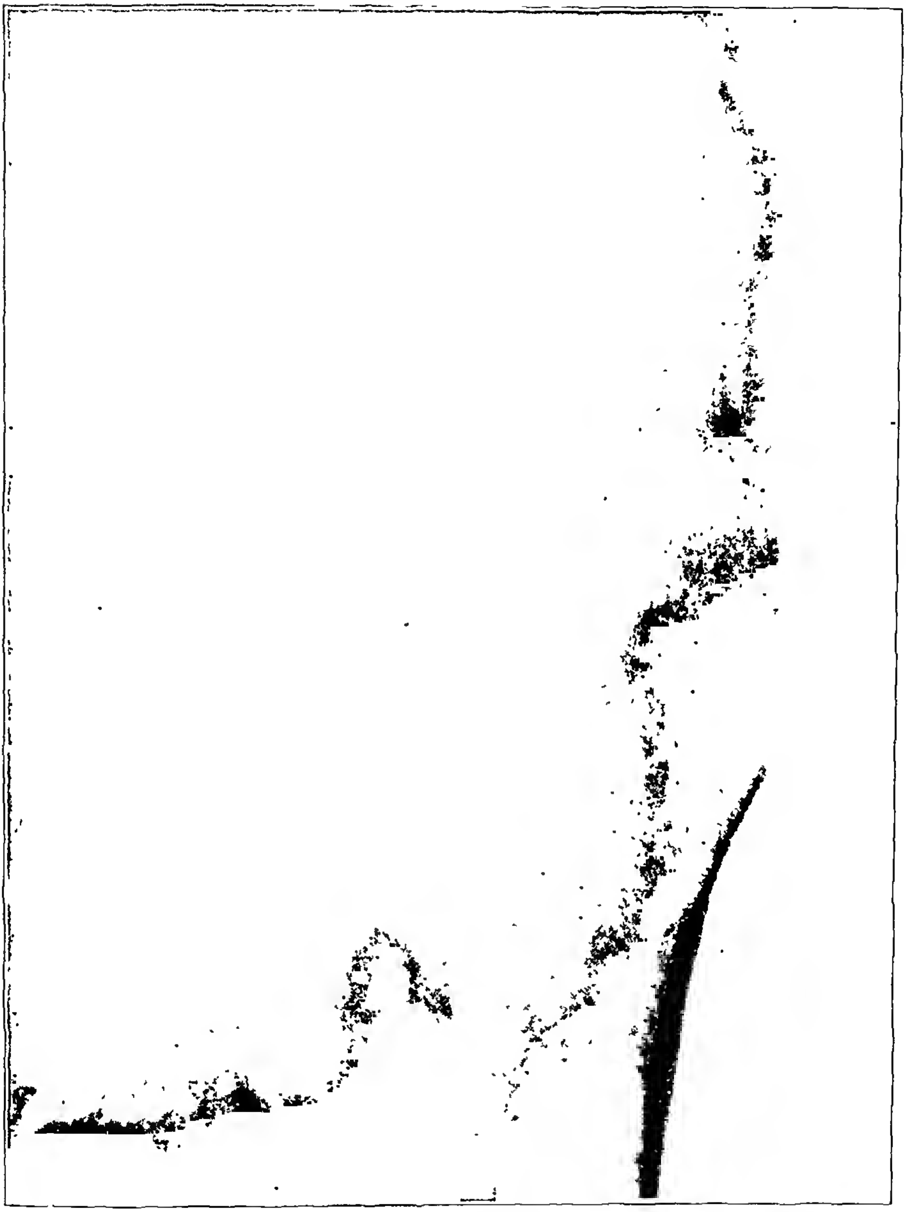

Fig. 3

Roentgenogram taken February 12, 1941. There is further rarefaction of the head and some sclerosis along the fracture site, but no signs of metastasis.

some absorption of the neck and upward displacement. There was rarefaction of the bone but no definite signs of metastases (Fig. 2).

She was having very little pain, was getting about with one crutch, so decided against any form of therapy with the understanding that one of the reconstruction procedures could be carried out later if necessary and advisable.

The patient has not returned for further examination. On February 12, 1941, through the cooperation of a roentgenologist in the patient's home city, further roentgenograms were made. There was further rarefaction of the head and some sclerosis along the fracture site, but no signs of metastasis (Fig. 3).

CONCLUSION

1. With the advent of higher voltage irradiation there is an increased danger of damage to the deeper tissues in the irritated area.

2. Bone, as well as the soft parts, is subject to injury by the roentgen ray.

3. If radiation osteonecrosis involves the femoral neck, spontaneous fracture may possibly occur.

4. When there is pain about the hip joint following irradiation for gyneeological cancer, skeletal metastases should not be assumed without definite roentgenographic evidence.

5. In no way is the deep roentgen-ray therapy condemned, nor is its efficacy in pelvic malignancies questioned. We should continue its use and at the same time be alert to its unavoidable complications.

Appreciation is expressed to the Roentgenographic Department for assistance in preparing this report.

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AN UNUSUAL CASE OF ACTINOMYCOSIS

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This communication is presented to add to the published results of actinomycotic lesions submitted to surgical treatment. It is hoped that this record may assist others in the decisions to be made in the management of such cases.

CASE HISTORY

On May 31, 1939, a male patient, aged seventeen, complained of a dull pain and swelling in his right upper back.

About two months before, he had noticed some swelling about the third molar tooth of the right lower jaw associated with considerable pain. According to the dental examination on March 29, 1939, inflammation was limited to the periodontal membrane and the tissues immediately surrounding the affected tooth. Roentgenograms taken at that time showed a vertically impacted mandibular third molar on the right side. The occlusal surface was free of osseous structure and the impaction was due to lack of space. After preliminary hot saline irrigations, the tooth was extracted under local anaesthesia on March 30, 1939. Several sutures were used to close the wound. The patient was kept in bed a few days with routine irrigation of the socket. Healing was uneventful and he was dismissed April 11, 1939.

A short time later, while taking a bath, he noted an unevenness in his back when he leaned against the tub, and was able to palpate a swelling in the vicinity of his right upper back between the scapulae. It was at first small, but later increased in size and became tender. This was relieved by hot bathing. At about the time he first noticed the swelling he fell on his right side doing gymnastics at school and thought he had injured his back. He did not tell his parents about the swelling until a few days previous to seeing the author when, after playing several games of tennis, he noticed that his right arm became very weak and he could not continue the game. A relevant point regarding personal habits was that the patient chewed grass and leaves frequently.

A physical examination on May 31, 1939, showed a spare young man of asthenic habitus with a temperature of 98.8, pulse 72, and respiration 18. There was a tender diffuse swelling deep in the muscles between the vertebral spinous processes and the vertebral border of the right scapula, which extended from the levels of the third to the sixth thoracic vertebral spines. The skin was not attached and fluctuation was present. The scapula moved over the swelling on bracing back the shoulder. There was slight local elevation of temperature, but no redness of the skin. No other abnormalities were found. The gum of the previously involved molar was normal.

A provisional diagnosis of cold abscess was made and the patient was immediately admitted to the Hospital where the author inserted a wide-bore needle and aspirated approximately ten cubic centimeters of thick pus. On the following morning a bacteriological report of the smear gave the diagnosis of actinomycosis.

Roentgenographic examination showed:

1. The bone in the region of the posterior portion of the right mandible was normal.
2. There was no evidence of any disease involving the spine. The lungs were clear, with the haziness over the right upper chest probably due to the soft-tissue swelling in the upper posterior portion of the right thorax. There was a questionable area of

beginning bone destruction involving the sixth posterior rib in the region of the scapular line.

The report from the blood examination was:

Red blood cells—4,520,000
Hemoglobin—90 per cent.
Color index—1.01
White blood cells—8,500

In view of the fact that this case was diagnosed and prepared for operation without the presence of secondary infection or of sinus formation, a discussion took place regarding the best procedure. All agreed to the principle that treatment should be a resection of the whole area involved, if that were possible. It was also agreed that the infection had entered by the third molar tooth on the right lower jaw and that a track must run from that area to the area of the abscess. A conflicting point was the roentgenographic report that the sixth rib was eroded. If this were so, it would seem impossible to do a resection of the area without either removing a rib or opening the base of the abscess. It was decided before operation that the abscess probably lay under the rhomboid group and the trapezius. The methods discussed by which the resection could be carried out were:

1. The abscess could be aspirated as completely as possible and lipiodol injected in order to study the extent of the abscess, as it was agreed that unless this were known, one could not be sure of what was being done at operation. This was ruled out as an impractical method.

2. The abscess could be opened at the beginning and its contents washed out, and then, after its extent had been studied, it could be resected. This would entail allowing the contents of the abscess to contaminate the wound. Some considered that this would not make a difference if it were later washed out.

3. Dr. Miller suggested that, if the abscess were resected widely, there was a small chance that it might not be opened, depending on whether or not it extended to the rib. The results in a previous case treated in the Hospital seemed to be against this method. However, it was decided to proceed on these lines, since, if the abscess were opened from the deep aspect, that opening could be used for exposing the extent of the abscess cavity.

FIRST OPERATION

On June 6, 1939, an incision, about twelve inches long, was made over the abscess, extending from the upper free border of the trapezius downwards mid-way between the scapula and the dorsal spines. This incision was made to include an elliptical area of skin, two inches wide at its greatest width, to be removed with the abscess. The skin was then dissected back on each side for about two inches. The free lower border of the trapezius was defined and sectioned vertically upwards in relation to the scapula, and the rhomboids, major and minor, were severed from their attachment to the scapula. In this way, dissection down to the deep fascia overlying the semispinalis group of muscles was accomplished. The dissection then proceeded from below laterally under the serratus posterior superior and the aponeurosis of the semispinalis group of muscles. This aponeurosis was taken with the abscess as the latter was located directly upon it.

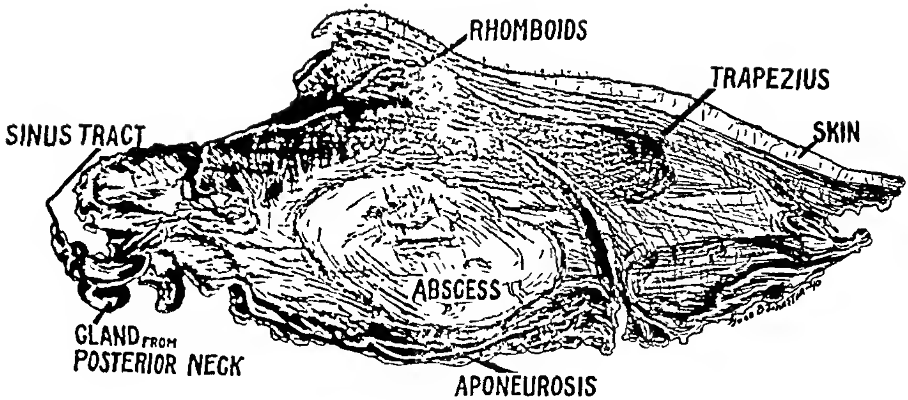

FIG. 1

Actinomycosis of back.

The dissection proceeded medially as far as the dorsal spines, which were cleared of the muscles and aponeurosis to the same depth. The whole mass was dissected upwards to the neck and into the lower part of the neck, under the levator scapulae muscle. At the deep part of the wound, a gland was seen which was removed with the mass and from its upper border, a cord, about the size of a piece of string and three inches in length, was removed. This was regarded as the track along which the infection had spread downwards to the gland and from there to the fascial plane under the trapezius and levator scapulae. The abscess was not opened at all during the operation and it was believed that the whole of the infected area was removed *en bloc.* The wound was irrigated with hydrogen peroxide followed by saline, and a few catgut stitches were used to hold the loose parts of muscle in place. It was considered before the operation that the whole wound should be left open as an ulcer to be later grafted, but in view of the clean dissection, the wound was sutured in its entirety with two small drains to evacuate any hemotoma.

Pathological Report

Macroscopic Examination. The specimen consisted of a piece of tissue measuring twenty by eight centimeters. One surface was covered with an elliptical piece of skin to which was attached subcutaneous tissue and muscle. On the deep surface there was a sinus tract eight inches long with a lymph gland the size of a marble at one extremity. Within the mass was a soft fluctuating area resembling an abscess. The specimen was fixed before opening.

Microscopic Examination. A large number of sections were taken through the tissue so as to give a topographical picture of the lesion. They showed an extensive inflammatory process which expressed itself as foci of purulent exudate, marked proliferation of fixed tissues, and fibrosis. The fibrotic area formed a wall separating the more active areas from the invaded muscle beyond. In the purulent areas the ray fungus could be identified.

The tract which appeared to extend up into the neck consisted of fibrous tissue, but no purulent area, and the gland which was sectioned separately showed catarrhal irritative changes with many germinal centers, but no histological evidence of the fungus.

Diagnosis. Exudative, purulent, proliferative, and productive inflammation of muscle due to actinomycosis.

SECOND OPERATION

On the twelfth postoperative day, the temperature, which for the previous two days had been normal, rose to between 99 and 100 degrees. The upper area of the wound at the level of the scapular spine became reddened and foul pus was discharged from the

small first stitch hole. The contents of the abscess were aspirated and examined microscopically. Some green negative actinobacilli and some fibrils were found. It was, therefore, decided to saucerize the wound immediately.

On June 20, 1939, the upper area of the wound was reopened to the extent of four inches, and an area of skin, two inches at its greatest width, removed. It was found that the abscess extended up to the area where the gland had been removed. This led to the belief that the infection had originated there. The wound was carefully cleansed, and packed with 20-per-cent. thymol in olive oil. The dressing was repeated daily.

Pathological Report

Macroscopic Examination. The specimen consisted of a piece of skin and subcutaneous tissue eight by one by one centimeters in size. In the center of the skin there appeared to be a partially healed incision which was greenish in color and appeared to be covered by a purulent, dense, solid exudate. The subcutaneous tissue oozed greenish pus on pressure. There was considerable dense, white, fibrous tissue in the subcutaneous tissue and little fat.

Microscopic Examination. The section showed a skin surface with a V-shaped ulcerated area which extended down to the subcutaneous tissue. The ulcer had a necrotic base and was lined by inflammatory granulation tissue, more fibrotic in the deeper portion. No actinomycosis could be demonstrated histologically in this tissue.

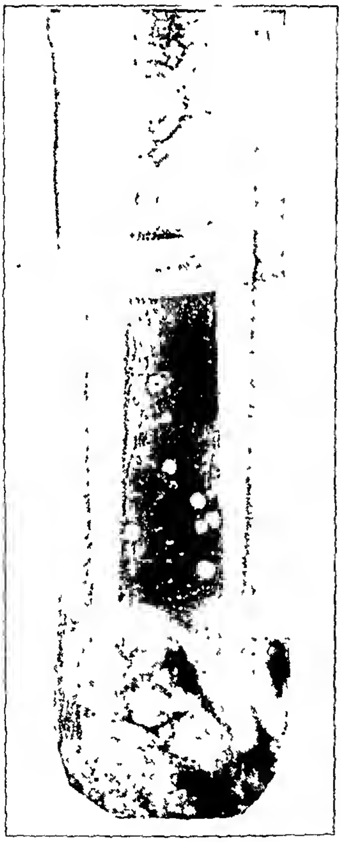

FIG. 2

Actinomyces grown in Robertson's meat. Note the rosettes adherent to the wall of the test tube.

THIRD OPERATION

Another abscess developed three inches below the first secondary abscess, so on June 27, 1939, the whole of the original scar around the sinus was removed, leaving a wound twelve by four inches to heal by granulation. The wound was packed with 20-per-cent. thymol in olive oil.

Pathological Report

Macroscopic Examination. The specimen consisted of a piece of skin and subcutaneous tissue measuring four by two by one centimeters.

Microscopic Examination. Sections showed an overlying skin surface beneath which, in the subcutaneous tissue, were numerous tracts filled with purulent exudate and proliferation of fixed tissues, and through which extended an inflammatory tract leading down to a large area of inflammatory granulation tissue in the subcutaneous regions. No actinomycosis could be identified in this histologically.

BACTERIOLOGICAL INVESTIGATION *

The material received at the laboratory consisted of five cubic centimeters of thick, dirty, yellowish-colored pus. Careful macroscopic examination showed numerous small pale-yellow granules. On fresh microscopic preparations of formol saline, lactophenol, and lactophenol with Amann blue, the characteristic granules of an actinomycotic infection could be seen. Each granule was formed by many rosettes consisting of a central mass of mycelium surrounded by clubs of different sizes. Smears

* The bacteriological investigation was made by L. P. Demers, M.D., and M. F. Howie, M.D.

Fig. 3

Actinomyces grown on blood agar. Colony of Type 1 (× 10).

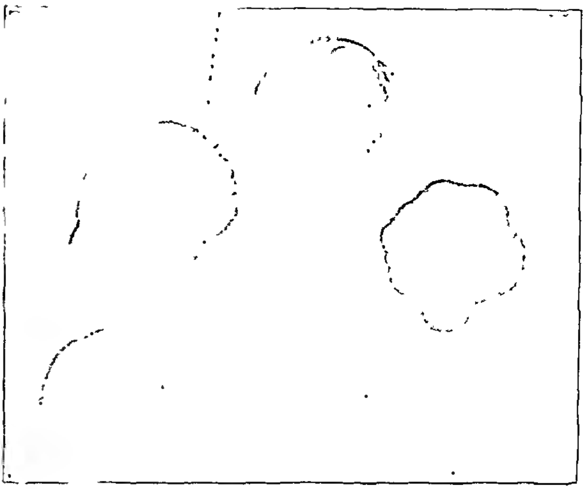

Fig. 4

Actinomyces grown on blood agar. Colony of Type 2 (× 10).

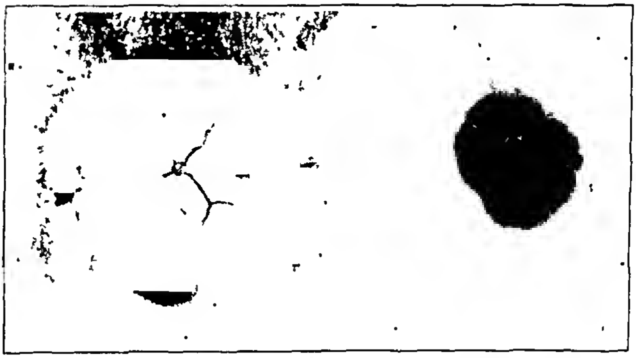

Fig. 5

Actinomyces grown on plain agar after two weeks of incubation. Colony of Type 2 (× 10).

of the pus stained by Gram's method showed large numbers of pus cells; large numbers of irregularly stained, twisted, S-shaped or spiral gram-positive filaments which varied in length and width; long, slender, gram-negative filaments; and small gram-negative coccobacilli. The aerobic culture yielded no growth. The anaerobic culture after two weeks' incubation in a Fildes-McIntosh jar yielded:

I. Two types of actinomyces of the Wolff-Israel type.
II. One type of anaerobic gram-negative filament.
III. One type of anaerobic gram-negative coccobacillus.
IV. One type of anaerobic gram-positive coccus.

All these were obligate anaerobes.

I. Actinomyces of the Wolff-Israel Type

On blood agar these actinomyces developed two types of colonies:

Type 1 was rather soft, and not adherent to the substratum. The colony of this type had the form of a rosette with the central part raised and moruloid. The peripheral part was divided into lobes by several grooves radiating from the center to the periphery like the spokes of a wheel.

Type 2 was very hard to crush, very adherent to the substratum, and partly embedded in the medium. The colony of Type 2 also had the form of a rosette, but was without any definite pattern (mammillated).

These actinomyces grew well in liquid media, with the exception of tryptone water. The liquid remained clear, and rosettes formed and collected at the bottom of the test

tube or adhered to the wall. These actinomyces also grew well on ordinary solid media, such as plain agar, blood agar, Sabouraud's agar, glucose tartaric acid, corn syrup, plain potato and glycerine potato; but they failed to grow on Chandelier's or McConkey's agar. They did not form spores or aerial hyphae, did not produce true pigment although they developed a pale yellow color, or liquefy gelatin in which they grew fairly well, or produce any hydrogen sulphide (H_2S). They acidified milk without the formation of a clot, and fermented the following Hiss sera sugars (with acid reaction and clotting of serum): lactose, salicin, dextrose, maltose, raffinose, levulose, and starch, but did not ferment mannite, glycerine, inulin, sorbite, or galactose. Gram's smears from the cultures showed that the mycelia lose their morphology and resemble diphtheroids. Granules treated by absolute alcohol for a few minutes, or by potassium hydroxide (KOH) failed to grow on Sabouraud's agar or in Robertson's meat.

II. Gram-Negative Filaments

On blood plates these organisms formed at first small rosettes resembling a minute daisy, but, as they continued to grow, formed a large pin-head colony with effuse arborescent edges, which grew in the depth of the medium. The Gram's smear showed long slender gram-negative filaments, which grew well in the usual liquid media with the exception of tryptone water. In pneumobroth there was formation of paillettes which adhered to the walls of the test tube or collected at the bottom. They also grew on ordinary solid media, such as blood agar, or plain agar. They did not show any visible growth on corn syrup, glucose tartaric acid, Sabouraud's agar, plain or glycerine potato, or Chandelier's or McConkey's agar. They grew in gelatin without liquefaction. Their reaction in lead acetate was negative; in litmus milk, neutral. There was no reaction in Hiss sera.

III. Gram-Negative Coccobacillus

This gram-negative coccobacillus grew on blood agar as a small pin-head, slightly raised, semiopaque colony. It grew poorly in usual liquid media, and failed to grow in tryptone water. It also grew poorly on blood agar, and plain agar, and failed to grow on Chandelier's or McConkey's agar, glucose tartaric acid, or corn syrup. Its reaction in litmus milk was slightly acid, but it formed no clot. It grew in gelatin without liquefaction. Its reaction in lead acetate was strongly positive. There was no reaction in Hiss sera.

IV. Gram-Positive Coccus

This gram-positive coccus grew on blood agar as a small, conical, semiopaque colony with faint beta hemolysis. It grew well in ordinary liquid media, such as glucose broth and peptone broth, but failed to grow in tryptone water. It grew on ordinary solid media, such as blood agar and plain agar, but failed to grow on Chandelier's or McConkey's agar. It fermented the following Hiss serum sugars: lactose, dextrose, saccharose, maltose, and starch, but did not ferment mannite, salicin, raffinose, inulin, levulose, glycerine, galactose, or sorbite. Its reaction in lead acetate was negative; in litmus milk, acid, but without clot. It grew in gelatin without liquefaction.

FURTHER TREATMENT

General Treatment. This was carried out as for tuberculosis with stimulating diet and general exposure of the body to sunlight and fresh air.

Specific Treatment. Iodides were begun on June 7, 1939, and gradually increased to a maximum of 300 minims of Lugol's iodine a day, which was reached on July 8, 1939. They were gradually diminished until cessation July 14, 1939. The iodides caused considerable digestive disturbance. A course of vaccine therapy was given by Dr. Hugh Starkey beginning July 15, 1939, and continuing with weekly injections for six weeks.

Local Treatment. After the third operation the wound was dressed with 20-per-cent.

thymol in olive oil, and exposed to direct sunlight for increasing periods. Later these dressings were alternated with alphamel. On July 16, 1939, the patient was discharged to the country where the treatment was continued. For three weeks he was at the seaside where the wound was exposed both to sunlight and sea water. His general and local condition improved rapidly and on October 10, 1939, the wound was completely healed.

At that time graduated exercises of the muscles of the shoulder region were begun and resistance exercises were also given to increase their tone.

On May 15, 1940, the wound was sound. The patient was playing tennis, and had skied and played hockey during the latter winter months. Full movements were possible in his shoulder with little winging of the scapula or depression of the prominence of the shoulder. (See Figures 6-A and 6-B.)

Since then he has been readmitted for excision of the scar. The area was covered by Thiersch and pinch grafts, and on September 14, 1940, was completely healed. There has been no recurrence.

DISCUSSION

After the first operation the question arose as to whether the best method was used and whether it would be possible on another occasion to carry it out in a more advantageous manner. As a result of the operation, the whole of the trapezius muscle attached to the scapula (but not the clavicular head) with the rhomboids, major and minor, were removed. The serratus anterior was left as was the levator scapulae and it was a question as to what stability the scapula would have in the movements of the shoulder. Theoretically speaking, the whole of the trapezius could have been divided and resutured back in place, had the extent of the abscess been known. This would have given better functioning of the scapula.

Further, the primary suture of the wound might be criticized in the light of the subsequent course. The author feels it achieved a most

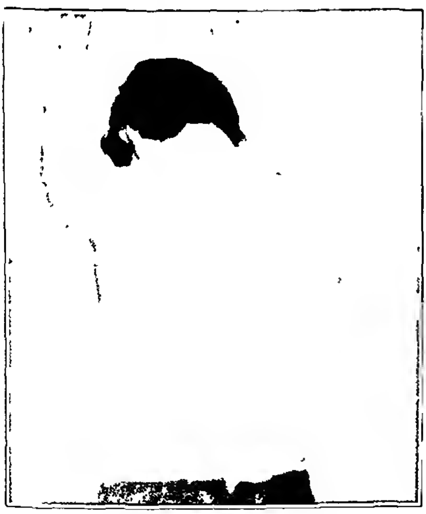

Fig. 6-A

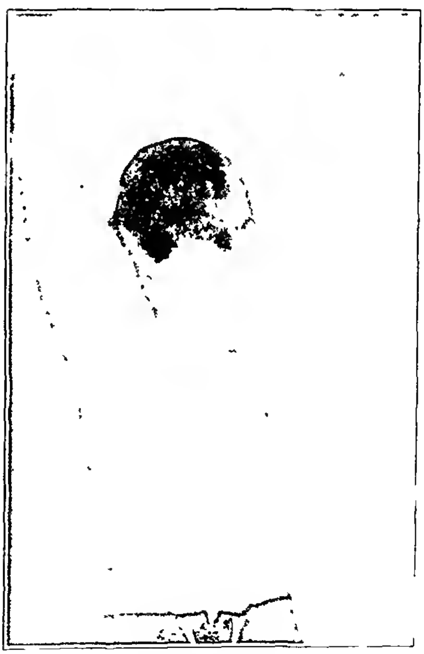

Fig. 6-B

Photographs showing range of motion fourteen months after third operation.

important result,—that is, the complete sealing of the large space under the scapula and serratus anterior in continuity with the wound of the operation when the trapezius and rhomboids were removed.

This case is unusual in several ways. In the first place, the location of the abscess is uncommon. No case with the abscess in this location is mentioned in Cope's monograph. Further, the history and dissection correlated and traced the entry of the organism very definitely to the third molar tooth. Again, it is unusual for the diagnosis to be established before secondary infection has been introduced. Finally, it is unusual in such a situation to be able to resect the whole, or practically the whole area involved. The author is also amazed to find the splendid functional result in the shoulder considering the extensive removal of muscles. It is hoped that this is a cure. Should a recurrence occur, it will be reported.

The author wishes to acknowledge the valuable help given him in this case by C. J. Tidmarsh, M.D., and Gavin Miller, M.D.

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OSTEOCHONDROMATOSIS

BY CLIFFORD LEE WILMOTH, M.D., F.A.C.S., PITTSBURGH, PENNSYLVANIA

Osteochondromatosis is a relatively uncommon pathological condition in which multiple intra-articular cartilaginous bodies form. These live in the joint cavity either as attached or free bodies. The etiology of this condition continues to be in doubt, and the part which infection, trauma, embryonic rests, and neoplastic changes play in their production is a matter of considerable difference of opinion. This report covers a ten-year period starting in 1930. During this period nine patients with osteochondromatosis have been seen, six with involvement of the knee joint, two of the elbow, and one of the hip. The patients were all males varying in age from twenty-six to sixty-four years.

CASE 1. A male, aged sixty-four years, for eight years had experienced pain in the left knee joint, and for six years had been aware of a hard nodular mass in the popliteal region. He had quite a pronounced limp on walking. Examination showed a marked instability of the left knee joint, a mass of hard irregular bodies which could be palpated in the popliteal area, and a quite marked atrophy of the muscles of the left thigh and calf. The roentgenogram showed the popliteal mass to be made up of multiple cartilaginous bodies (Fig. 1-A). Through an anteromedial incision all loose bodies were removed

FIG. 1-A

Case 1. Roentgenogram shows osteochondromatosis of the knee joint in the non-active stage. The bodies are almost all in the posterior pouch, and many were found deeply buried in the soft tissues of the popliteal area.

FIG. 1-B

Case 1. Photograph of the loose bodies removed from the knee joint.

(Fig. 1-B). No attempt was made to remove those bodies which had penetrated into the tissues outside the synovial membrane and which were well embedded there. The patient was followed for a period of slightly over two years. When seen at the end of ten months, there was still marked instability of the left knee joint with associated muscle atrophy. The pain, however, had been largely removed by the operative procedure. When seen again slightly more than two years postoperatively, the clinical picture was unchanged. The roentgenogram failed to show the formation of any new loose bodies, and the ones which were embedded in the tissues of the popliteal area had not changed in size or position.

CASE 2. A male, aged forty-six years, came to the hospital because of pain in the left hip of two years' duration. Examination showed slight limitation of motion as compared to the right hip. There was very slight atrophy of the thigh muscles. The diagnosis was made by roentgenogram which showed the joint capsule filled with osteocartilaginous shadows (Fig. 2). Through a Smith-Petersen incision the hip joint was opened and the small loose bodies removed. The patient was seen only once, eight months after leaving the hospital. There was no pain and no limitation of motion nor any appreciable atrophy of the thigh muscles. The roentgenogram failed to show any recurrence of osteocartilaginous bodies.

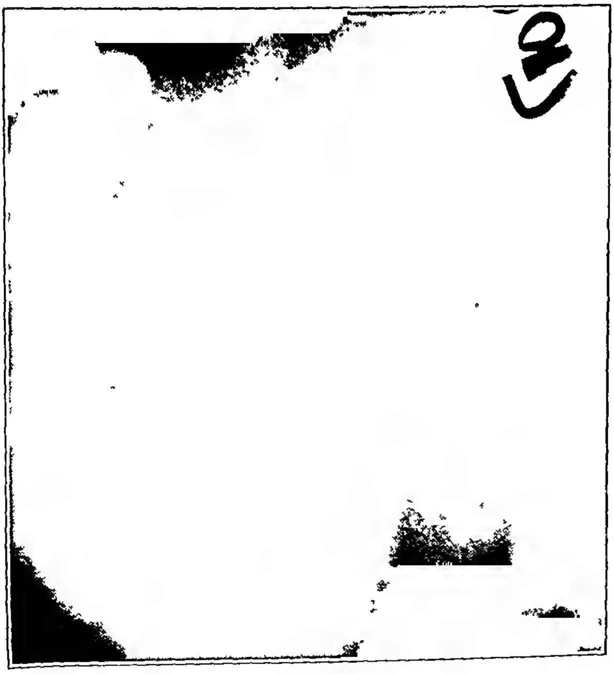

FIG. 2

Case 2. Roentgenogram shows osteochondromatosis of the hip joint.

CASE 3. The patient was a male, aged thirty-two years, who for a year had noticed occasional twinges of pain in the right elbow. Physical examination was essentially negative for any objective pathology. The elbow joint showed no tenderness or swelling, nor was there any atrophy present. Motion was not limited. The roentgenogram showed osteocartilaginous bodies of small size in both the olecranon fossa and the anterior joint space. Bilateral incisions were made and all the loose bodies found were removed. All the synovial tissue which could be reached was excised, especially that about the epicondyles at the synovial-cartilaginous junction. Recovery was uneventful and the patient when last seen was free from pain al-

though the postoperative roentgenogram had shown a few minute bodies which had been missed at the time of operation. This patient could not be located for later follow-up records.

CASE 4. The patient was a male, aged thirty-six years, who complained of pain and slight swelling of the left elbow joint for a period of four years. The motion of the joint was becoming less, and he had been aware of a firm hard mass in the anterior aspect of the joint for a year. Upon examination there was limited flexion, extension, and rotation of the left elbow joint, and moderate atrophy of the muscles of the left forearm. The grasp of the left hand was decreased. The roentgenogram showed multiple osteocartilaginous bodies filling the anterior joint space and the olecranon fossa (Figs. 3-A and 3-B). Through bilateral incisions into the elbow joint the loose bodies (Fig. 3-C) were removed and a partial synovectomy was done. That part of the synovial membrane which had attached cartilaginous bodies, or which showed definite changes, was removed. The patient was seen after eight months and again after three years. There was very slight residual loss of rotation of the radius, and there was a loss of 10 degrees in extension. A few small bodies missed at the time of operation showed no apparent change in size or number in roentgenograms after three years. Subjectively the results were quite satisfactory.

CASE 5. A farmer, aged fifty-two years, because of rheumatism in the right knee, had had a roentgenogram taken by his family doctor five years previously. It was found then that the knee joint contained many osteocartilaginous bodies. Roentgenograms taken at the time he was first seen by the writer failed to show any apparent alteration in the number or size of the bodies when compared with the roentgenogram taken five years before. The cartilaginous bodies were largely in the posterior compartment, with a few scattered loose bodies in the suprapatellar space. He stated that his symptoms had remained unchanged, and that he was able to do his farm work with only occasional discomfort. Because of the loose bodies in the anterior compartment, he was advised to have the knee operated upon, but this he declined to do. While no further change in size or number of the loose bodies was expected, it was believed that damage to the joint surfaces would occur if the cartilaginous bodies were not removed. This patient, replying to a follow-up letter three years after the last examination, stated that he had not noticed any appreciable change in the knee since the previous examination.

CASE 6. A salesman in a department store, aged fifty-eight, had experienced occasional periods of pain and swelling of the left knee over a period of eight years. The swelling of the knee joint followed sudden severe attacks of pain in the joint, and gradually subsided with rest and heat. The interval between attacks had been variable, but they were becoming more frequent, with more discomfort present between the attacks of severe pain and swelling. Examination showed slight instability of the knee joint. The patient walked with a limp and with the aid of a cane. There was moderate atrophy of the calf and thigh muscles. In the suprapatellar space a large loose body could be palpated. The roentgenogram showed multiple osteocartilaginous bodies. An anteromedial incision was made, and the loose bodies were removed. The synovial membrane adjacent to the articular cartilage of the femur was reddened and thickened, particularly over excrescences of soft cartilaginous material, and this was excised. This patient was seen at frequent intervals over the following four years. At the end of that time he still walked with a slight limp, and complained of some aching pain particularly in damp weather. His symptoms were those usually complained of in connection with arthritic changes. A recent roentgenogram shows definite arthritic changes, but no recurrence of osteocartilaginous bodies.

CASE 7. This patient was a male, aged twenty-six, who for two years had experienced painful swellings of the right knee joint. The examination was essentially negative except for the palpation in the suprapatellar space, of a freely movable hard body. The roentgenogram showed multiple osteocartilaginous bodies which were removed through

FIG. 3-A FIG. 3-B

Case 4. Lateral and anteroposterior roentgenograms showing osteochondromatosis of the left elbow joint. The bodies are largely in the anterior compartment and in the olecranon fossa.

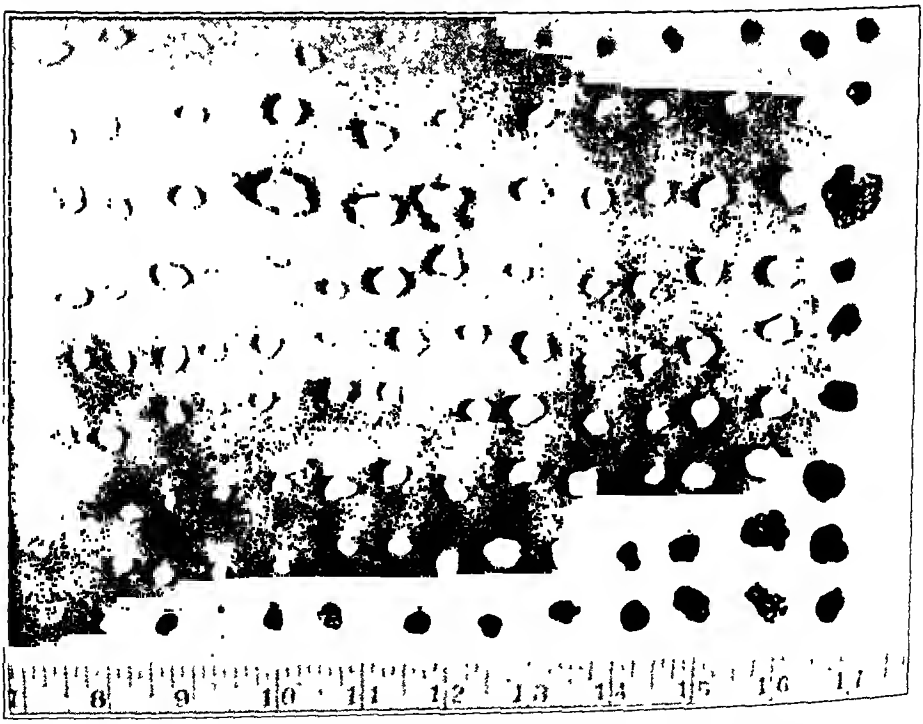

FIG. 3-C

Case 4. Photograph of the loose bodies removed from the elbow joint.

an anteromedial incision into the knee joint. The synovial membrane at the synovia-cartilaginous junction was reddened and thickened, and was excised. Soft excrescences of cartilaginous material were removed with a curette. This patient has been seen at intervals over the past three years. Pain of some arthritic type has been experienced occasionally. There is no limitation of motion and no demonstrable muscle atrophy. Roentgenograms show no recurrence of loose cartilaginous bodies. The embedded bodies in the popliteal area, which were not removed at the time of operation, have remained unchanged in size and location.

CASE 8. This patient was forty-two years old. He complained of rheumatic pains in both knees of three years' duration. Physical examination was essentially negative. Roentgenographic examination of both knees showed multiple osteocartilaginous bodies about the superior aspect of both patellae. An arthrotomy of each knee was done. The cartilaginous bodies were found attached to the synovial membrane bordering the patellae. The bodies, together with the synovial membrane, were removed. This patient was seen six and seventeen months postoperatively. On each occasion the roentgenogram showed no new bodies forming. There was no objective evidence of pathology present. He stated that he still had occasional arthritic pains in the knee joints.

CASE 9. The patient was a man of forty-five years. He complained of occasional pain and discomfort in the left knee joint, which had been present at intervals for a period of five years. Slight swelling of the joint occasionally accompanied the attacks of pain. Physical examination was essentially negative. There was no muscle atrophy, limitation of motion, or sign of effusion. An anteromedial incision was made into the joint cavity, and the loose bodies were removed. An area five centimeters in length across the femur was apparently the source of the loose bodies. The synovial membrane in this area was bluish red, and there was a piling up of soft cartilaginous material. A partial synovectomy was done. This patient could not be followed postoperatively.

The difficulties of a satisfactory follow-up system are apparent to all who attempt it. These patients were for the most part industrial workers who, because of the economic conditions of the last ten years, seldom remained long in one location. Even follow-up letters failed to reach them or were of little help. In changes as slowly progressive as benign osteocartilaginous growths, it would be much more interesting and helpful if a careful check could be made over a period of at least ten years. The longest period of this series of cases was four years.

The few cases that have been studied have shown two characteristics,—the distribution of the cartilaginous bodies in the joint cavity has been fairly constant, and localized synovial osteocartilaginous proliferation has been found at the synovial cartilaginous junction. The knee joint may be taken as an example. Most loose bodies were found in the posterior pouch, a few in the suprapatellar pouch, and an occasional body in other recesses of the joint cavity. Apparently most of the cartilaginous bodies gravitate into the more dependent portion of the joint which is the *posterior pouch. As the bodies increase in size,* they produce distention of the normal joint cavity which often progresses to sacculations or diverticuli from the main joint cavity. As Rixford[1] has stated, "It is as though the cartilaginous masses backed out through areas of least resistance carrying the expanded synovial membrane before them".

The appearance of the synovial membrane differed widely. When the cartilaginous bodies were in the posterior pouch of the knee joint,

FIG. 4

High-power photomicrograph shows the superficial zone of one of the small bodies in the active stage. The outer layer is a very cellular area of fibrous tissue,—the perichondrium. The deeper structure is fibrocartilage.

FIG. 5

Photomicrograph of a mature osteocartilaginous body. The superficial layer is formed of dense fibrous tissue,—the perichondrium. Well-formed fibrocartilage exists beneath this, and areas of lime-salt deposits are seen in the osseous area.

FIG 6

Photomicrograph of an old non-active loose body which has ceased to grow. The superficial layer of fibrous perichondrium is thrown into folds and there is some exfoliation of the cells on the surface. The center of the body is made up of cartilage and bone As calcification of the cartilage cells occurs, they appear more round and stand out distinctly because of the calcium deposit around the cell In general it may be stated that the histological examination reveals a fibrous proliferated layer which passes over into hyaline cartilage, which in turn changes to calcified cartilage. Lamellae of bone which form are free from haversian canals and bone marrow.

the synovial membrane in the suprapatellar region showed little change or at most only a congestion and a slight thickening. Where the cartilaginous bodies were scattered throughout the joint cavity, the entire synovial membrane was thickened and irregular in contour.

The relative absence of subjective symptoms, compared to the marked internal derangement of the joint, was striking. There was seldom a demonstrable increase in joint fluid, and no local heat or redness

FIG. 2
April 15, 1940

FIG. 3
April 25, 1940

per respiratory infection, and was treated by the family physician, who prescribed cod-liver oil, which was soon discontinued because the child vomited. One month previous to admission to the hospital the lower extremities had become more swollen, and there was bilateral swelling and enlargement of the shoulders. These enlargements gradually increased in size, and the child failed to gain weight.

Physical examination revealed a poorly developed and undernourished, white, female child, nine months of age. The skin was pallid, dry, and wrinkled. The anterior cervical and inguinal lymph glands were palpable. The anterior fontanel was open one and one-half finger-breadths, and the posterior fontanel was closed. The thorax was flattened in its anteroposterior diameter, and a marked rachitic rosary was present. The heart and lungs were normal; the abdomen slightly distended; and the extremities, thin and underdeveloped, showed a rather marked generalized hypotonicity. There was little voluntary motion, and passive motion of the extremities caused the child to cry. An abnormal enlargement of both deltoid regions was very noticeable. The right knee was larger than the left, and there was a fusiform swelling of the left thigh. The reflexes were normal.

The laboratory findings were as follows:

Red blood cells—2,180,000
Hemoglobin—5 grams
White blood cells—21,500
Polymorphonuclear neutrophiles—31 per cent.
Small lymphocytes—68 per cent.
Eosinophiles—1 per cent.

There was a marked anisocytosis and poikilocytosis, and three normoblasts per 100 white blood cells were seen in the differential.

Urinalysis was negative.

A provisional diagnosis of advanced scurvy was made.

Roentgenograms of the entire body were taken on admission to the hospital. These showed wide separation of the upper humeral epiphyses and calcified subperiosteal hemorrhage about the humeri, femora, tibiae, and fibulae. There was an old healed fracture of the right clavicle. The epiphyseal lines of the bones of the lower extremities were widened and irregular, showing a definite *Trummerfeld*.

On admission to the hospital the patient was given small blood transfusions, and vitamin-C therapy,—250 milligrams in twenty-four hours.

On April 19, 1940, the blood picture was as follows:

Red blood cells—4,260,000
Hemoglobin—13 grams
White blood cells—5,800
Polymorphonuclear neutrophiles—72 per cent.
Small lymphocytes—27 per cent.
Eosinophiles—1 per cent.

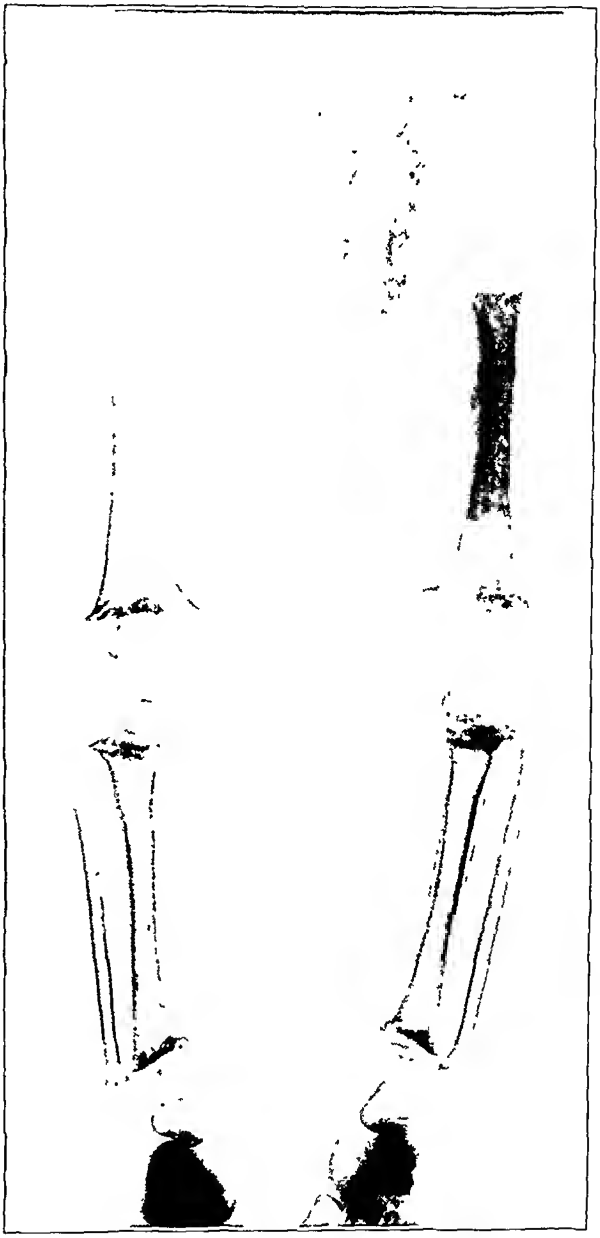

Fig. 4
May 23, 1940

The epiphyseal separations of the humeri were treated by manipulation under general anaesthesia, and the application of a double body spica with the arms in wide abduction.

Anteroposterior x-rays made on April 25, 1940, with the child in the cast (Fig. 3) showed fairly satisfactory reduction of the epiphyses of the humeri.

The child continued to improve, took food satisfactorily, and lost all tenderness on

of the joint tissues. The size and number of the loose bodies was the chief factor in giving objective evidence of joint pathology. Several patients with knee-joint involvement walked with a limp. Except for occasional sharp pains, the general subjective symptoms were those usually complained of in arthritic joints. In four of the patients with knee-joint involvement, the cartilaginous bodies could be palpated either in the suprapatellar space or in the popliteal area. The diagnosis was confirmed in all cases by roentgenograms which gave a picture of multiple loose or attached osteocartilaginous bodies in the absence of, or with relatively little, other joint pathology.

Surgical removal of the osteocartilaginous bodies was advised in all instances. The difficulty of removal of all the bodies in the knee and elbow regions is apparent from postoperative roentgenograms. No effort was made to remove the cartilaginous bodies which had made their way through the synovial membrane of the posterior pouch of the knee joint. It was believed that these encapsulated bodies would cause no symptoms, would not change in size or position, and that their removal would not be without danger to important structures which pass through that region. An effort was made to remove every loose body or those which might become loose. It was believed that this was necessary if further joint damage was to be avoided. A partial synovectomy was done whenever the synovial membrane showed definite changes. Whether removal of the synovial membrane and the osteocartilaginous bodies will prevent a recurrence of the condition is unknown. In the few cases which were followed there was no recurrence of the formation of the osteocartilaginous bodies.

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COMPLETE BILATERAL EPIPHYSEAL SEPARATION OF THE UPPER HUMERAL EPIPHYSES DUE TO SCURVY

Report of a Case

BY RICHARD T. HUDSON, B.S., M.D., F.A.C.S., DENMAN C. HUCHERSON, A.B., M.D., AND ALVIN B. ORTNER, A.B., M.D., LOUISVILLE, KENTUCKY

Cases of scurvy with minor epiphyseal changes and subperiosteal hemorrhage are not rare, but the complete separation of both upper humeral epiphyses is unusual.

Skeletal changes of this magnitude result only from scurvy of severe degree, and after many weeks of avitaminosis.

In a review of the literature since 1917, the authors have not been able to find a similar case, with such extensive osseous changes.

CASE REPORT

W. L. D., a nine-months-old, white female, was admitted to the Children's Free Hospital on April 12, 1940. According to the parents the child was very nervous and resented handling because of apparent generalized tenderness. The family history was essentially negative; the patient was the youngest of ten children, the other nine living and well. The child had not been able to sit alone. Her diet since birth had consisted of one small can of Pet milk daily, diluted with water and Karo, and given in divided feedings. She had had no orange juice, cod-liver oil, cereals, or vegetables in her diet.

Three months prior to admission, the mother noticed that the right ankle was swollen and tender. This was followed by swelling and tenderness of the right knee and later the left lower leg, and then generalized tenderness on handling the patient. Three weeks after the onset the patient developed an up-

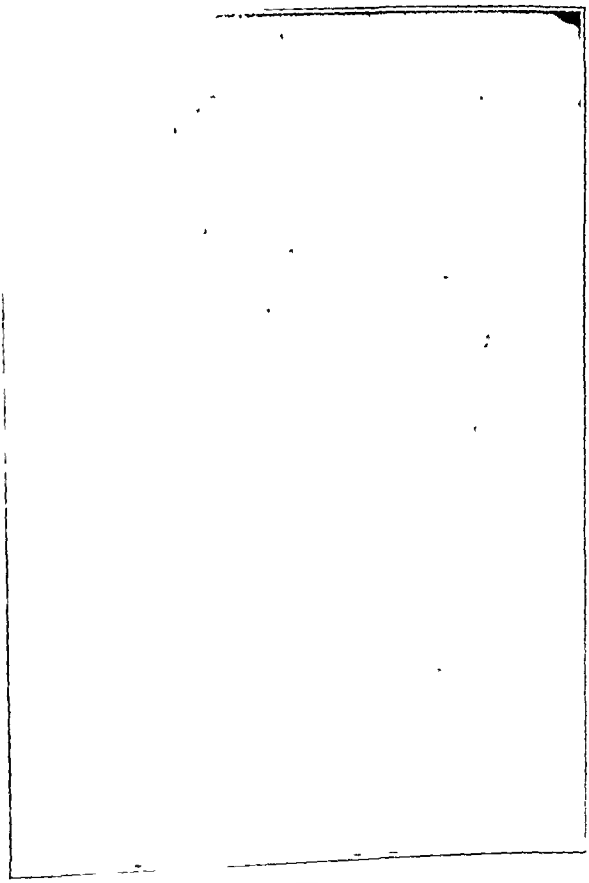

Fig. 1

April 15, 1940

Fig. 2
April 15, 1940

Fig. 3
April 25, 1940

per respiratory infection, and was treated by the family physician, who prescribed cod-liver oil, which was soon discontinued because the child vomited. One month previous to admission to the hospital the lower extremities had become more swollen, and there was bilateral swelling and enlargement of the shoulders. These enlargements gradually increased in size, and the child failed to gain weight.

Physical examination revealed a poorly developed and undernourished, white, female child, nine months of age. The skin was pallid, dry, and wrinkled. The anterior cervical and inguinal lymph glands were palpable. The anterior fontanel was open one and one-half finger-breadths, and the posterior fontanel was closed. The thorax was flattened in its anteroposterior diameter, and a marked rachitic rosary was present. The heart and lungs were normal; the abdomen slightly distended; and the extremities, thin and underdeveloped, showed a rather marked generalized hypotonicity. There was little voluntary motion, and passive motion of the extremities caused the child to cry. An abnormal enlargement of both deltoid regions was very noticeable. The right knee was larger than the left, and there was a fusiform swelling of the left thigh. The reflexes were normal.

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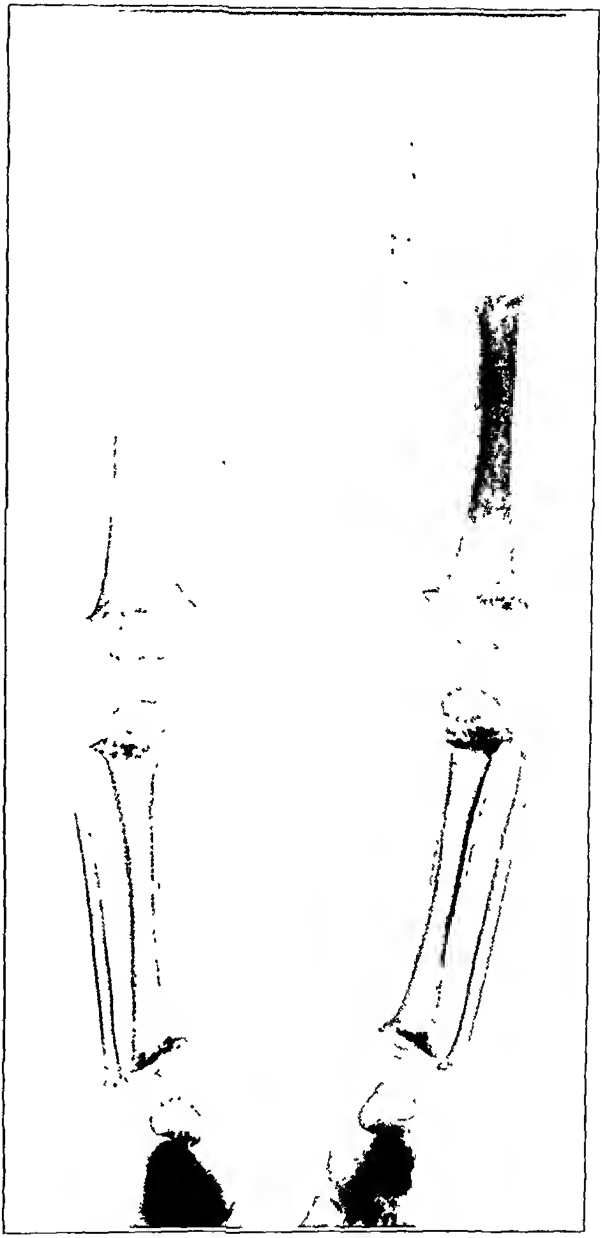

Fig. 4
May 23, 1940

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FIG. 5
June 4, 1940

handling. The cast was removed on June 4, 1940. Anteroposterior x-rays (Fig. 5) at this time showed the capital epiphyses to be in practically normal relationship with the shafts of the humeri. A marked persistent reaction and thickening about the bone ends were still present.

On her discharge from the hospital the family physician was advised to continue vitamin-C therapy.

On September 10, 1940, the physician reported verbally: "All the symptoms have disappeared, and the patient seems to be in excellent health."

LATERAL DISLOCATION OF THE HEAD OF THE RADIUS WITH FRACTURE OF THE ULNA

BY ROBERT A. WISE, M.D., NEW YORK, N. Y.

From the Fracture Service of the Knickerbocker Hospital, New York

Dislocation of the head of the radius, occurring as an associated lesion with a fracture of the shaft of the ulna, is often overlooked. The frequent coexistence of these two lesions, emphasized by Monteggia, makes it imperative to examine carefully the relationship of the radius with the capitulum in all fractures of the shaft of the ulna. The radial dislocation is usually anterior, but may be posterior or lateral; the ulnar fracture is commonly in the upper third, but may be in the mid or lower third of the shaft, or through the olecranon.

The following case report illustrates a lateral dislocation of the head of the radius associated with an incomplete fracture of the proximal end of the ulna.

CASE REPORT

M. K., a boy of seven, was admitted to Knickerbocker Hospital on November 6, 1940, complaining of a painful, swollen left elbow. He stated that, while sliding down an incline, he tripped and fell, striking his left elbow against a concrete step.

Examination revealed a tender, markedly swollen left elbow. The forearm was pronated and held at a right angle with the arm. No active flexion, extension, or supination at the elbow was possible. The head of the radius was abnormally prominent on the lateral aspect of the forearm and exquisitely tender. There was no injury to the ulnar, median, or radial nerves.

Roentgenograms (Figs. 1-A and 1-B) showed an incomplete fracture of the proximal end of the ulna with lateral angulation, and a complete lateral, and slight anterior dislocation of the head of the radius.

After careful skin preparation, open reduction was performed on November 13, 1940, through a posterolateral incision as described by Boyd. A blood-pressure cuff tourniquet was used, and Lane technique was observed throughout. The incision began above the lateral border of the olecranon and extended downward along the shaft of the ulna. The insertion of the anconeus and the origin of the supinator were reflected from the ulna subperiosteally, and the muscles retracted radially, exposing the upper third of the shaft of the ulna, and the head and neck of the radius.

Pathology. The elbow joint contained 10 cubic centimeters of liquid blood and several blood clots. The head of the radius was dislocated laterally, slightly forward, and was separated from the radial notch. There was a complete tear of the orbicular ligament at its insertion into the ulna, and the articular cartilage lining the radial notch was lacerated. The ulna was angulated radially and several incomplete longitudinal fracture lines were present (Fig. 2).

Procedure. The angulation of the ulna was corrected by direct light blows through a blunt instrument placed at the apex of the angulation. The dislocation of the radius was reduced by traction and supination of the forearm, and the torn edges of the orbicular ligament were approximated with mattress sutures of silk. Fine interrupted silk sutures were used to close the capsule, the reflected muscles, fascia, and skin. The elbow was placed at a right angle in a posterior molded plaster splint.

Fig. 1-A

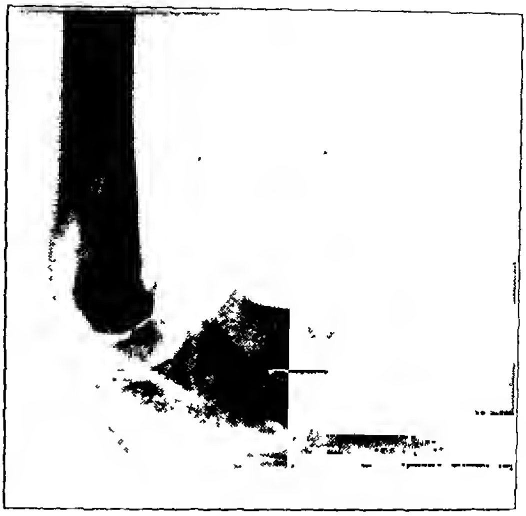

Fig. 1-B

Roentgenograms, before reduction, showing the lateral dislocation of the radial head with the incomplete fracture of the ulna. Note the slight anterior displacement of the radial head.

After-Care. The wound healed *per primam* and the patient was discharged on the seventh postoperative day. The splint was removed twenty days after operation, the arm placed in a sling, and active motion at the elbow encouraged. All motions at the elbow joint returned rapidly, and nine weeks after injury there was normal range of flexion, extension, pronation, and supination (Figs 3-A and 3-B).

This case illustrates an unusual Monteggia fracture, in which the fracture of the ulna is incomplete and the dislocation of the head of the

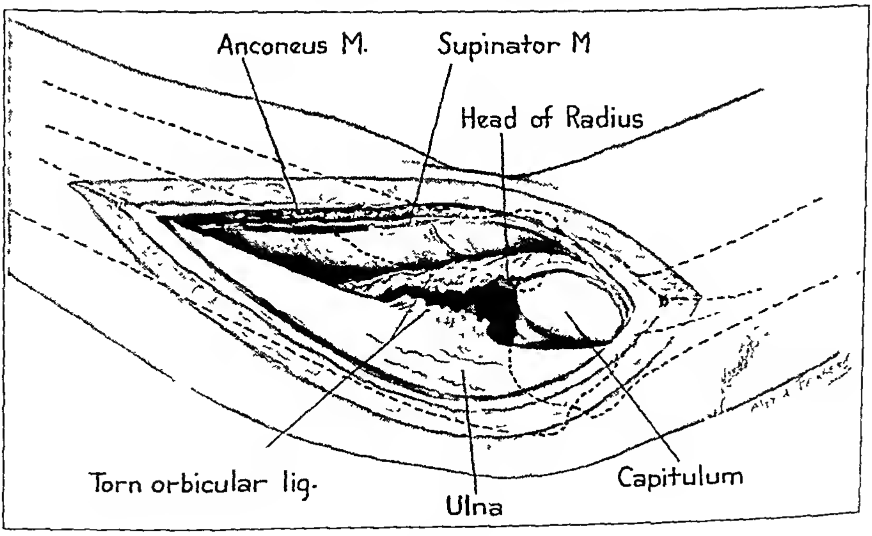

Fig. 2

Drawing made at operation. Note abnormal relationship of the radial head with the capitulum and the tear of the orbicular ligament.

radius is lateral. In Speed's report of sixty-two cases of Monteggia fracture the dislocation of the radial head was anterior in 83.3 per cent.

Fig. 3-A

Fig. 3-B

Roentgenograms after reduction. Note normal relationship of the radial head.

and lateral in only 6.7 per cent.

Boyd's incision is ideal for the operative treatment of patients with this injury, for it makes possible the exposure of the upper fourth of the radius and the shaft of the ulna through one incision, with complete protection for the deep branch of the radial nerve.

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ROENTGENOGRAPHIC STUDY OF THE CARPAL CANAL

BY VERNON L. HART, M.D., AND VALERIA GAYNOR, R.T.,
MINNEAPOLIS, MINNESOTA

The palmar surface of the bones of the carpus is concave from side to side. This deep concavity is named the carpal groove and is formed by the shape and position of the bones at the sides of the carpus. Prominent bone structures on the ulnar border of the groove are the pisiform bone and the hook of the hamate or unciform bone. The radial side of the groove is formed by the tuberosity on the navicular or scaphoid bone and the thick projecting crest or ridge on the greater multangular bone or trapezium. Arched over the hollow of the wrist or carpal groove, and firmly attached to the bony boundaries, is the extremely strong transverse carpal or anterior annular ligament. The ligament converts the groove into the carpal canal or tunnel (Fig. 1). Through the carpal tunnel pass the median nerve, the flexor digitorum sublimis, flexor digitorum profundus, and flexor pollicis longus tendons. The borders of the canal provide origin or insertion for seven of the intrinsic muscles of the hand as well as insertion for the tendon of the flexor carpi ulnaris muscle.

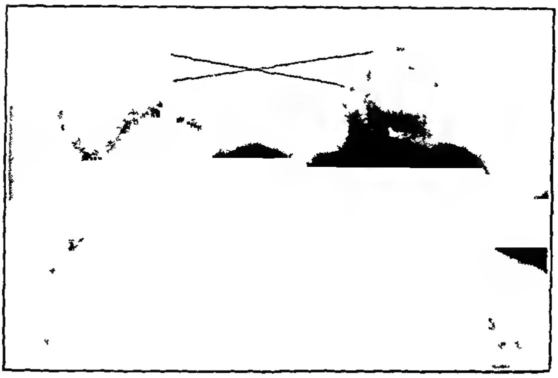

Fig. 1

Vertical roentgenogram of the wrist demonstrating (1) pisiform bone, (2) hook of the hamate or unciform, (3) tubercle of the navicular or scaphoid, and (4) crest of the greater multangular or trapezium. The crossed lines represent the transverse carpal ligament which converts the carpal groove into the carpal canal.

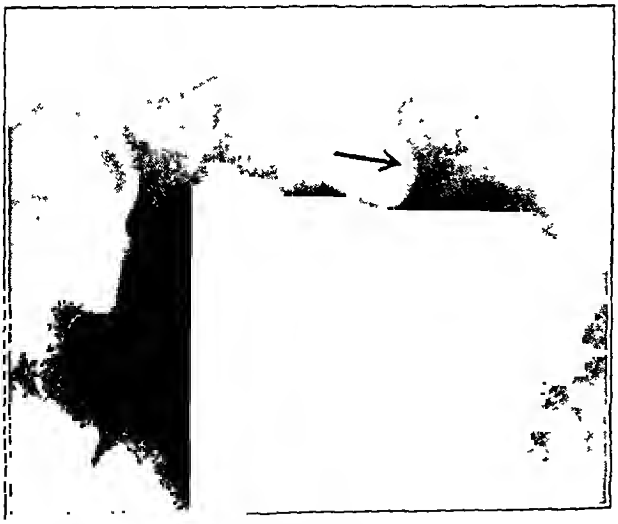

Fig. 2

Roentgenogram of the bony boundaries of the carpal canal which demonstrates a developmental defect or separate hook of the hamate.

The superficial branches of the ulnar artery and nerve cross the tip of the hook of the hamate, and the nerve can be felt slipping over the hook in the hypothenar eminence about two centimeters distal and

radial to the pisiform. The pisiform bone is easily palpated in the normal hand at the end of the flexor carpi ulnaris tendon. The tubercle of the scaphoid can be found at the point where the flexor carpi radialis tendon passes out of sight at the wrist. The crest of the trapezium is immediately distal to the scaphoid tubercle in the medial edge of the ball of the thumb; the two are often felt as one continuous bony prominence.

Very limited information is available regarding developmental anomalies (Fig. 2), injury (Fig. 3), or disease of the bony borders of the carpal canal. Additional knowledge would be gained if these anatomical structures were more frequently studied roentgenologically by the technique demonstrated in Figure 4.

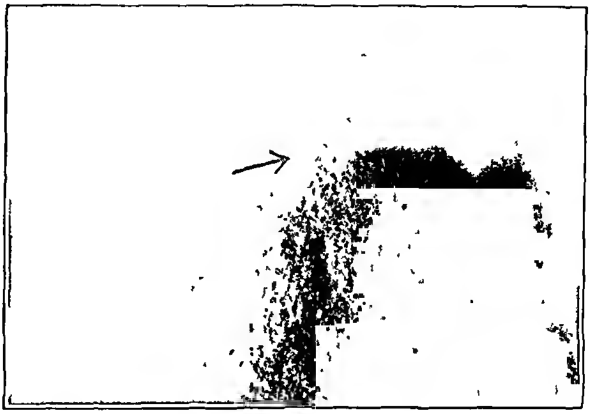

FIG. 3
Roentgenogram of carpal canal demonstrating a fracture or a developmental defect of the hook of the hamate.

FIG. 4
Photograph demonstrates the technique for obtaining a vertical roentgenogram of the bony boundaries of the carpal canal. The flexor surfaces of the patient's forearms should rest comfortably upon the x-ray table and the cassette. The hand should not be in ulnar deviation in order to prevent superimposition of the shadows of the pisiform bone and the hook of the hamate. The position of the x-ray tube will vary according to the individual patient. The central ray should be parallel with and in front of the third metacarpal bone. The standard distance used is thirty inches from focal point of x-ray tube and cassette. X-rays should be made of both right and left carpal canals.

AN OSTEOPERIOSTEAL CHISEL

BY R. E. BURNS, M.D., MADISON, WISCONSIN

There has been much discussion in medical annals as to what constitutes the periosteum. There is, however, little debate regarding the rôle of the osteoperiosteal graft in the situation in which it is indicated. The purpose of this article is to describe the difficulties ordinarily encountered in the removal of the graft, with a suggestion for their solution.

The medial aspect of the tibia is the customary site for the removal of the graft. Here the periosteum is thick, and the cortex is thick and, too often, brittle. If a straight chisel is used in the removal of the graft, difficulty is often encountered. If the angle of inclination of the chisel is *too small, the fibrous layer of the periosteum only is scraped off and very*

FIG. 1

FIG. 2

little of the element of osteogenesis remains. If, on the other hand, the angle of inclination is too great, large pieces of the cortex together with the periosteum are removed. The graft as removed usually consists of an alternating series of loosely connected fragments of periosteum holding together a series of cortical grafts.

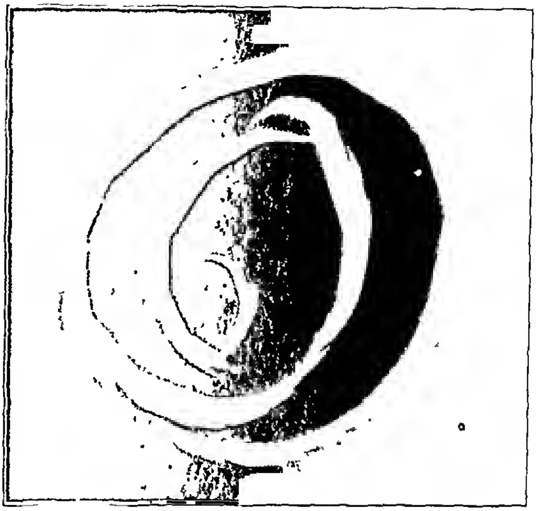

Fig. 3

It was thought that, if a chisel could be devised based on the principle of the plane gauge, it would ensure a graft of uniform thickness, which could be easily removed. The chisel is curved on the flat. Two guards prevent its penetration beyond three sixteenths of an inch. It can be driven abruptly into the bone until the guards are reached. Thereafter, due to the curve of the chisel, the hand of the operator in his removal of the graft parallels the bone. As the graft is removed it immediately curls up. This curling indicates the continuity of its substance. It can be molded to fit the desired location by cross hatching.

Figure 1 shows the chisel. Figure 2 shows the final step in the removal of the graft. Figure 3 shows a roentgenogram of the graft after removal.

TREATMENT OF FRACTURES OF THE NECK OF THE FEMUR BY INTERNAL FIXATION

Report of the Fracture Committee of the American Academy of Orthopaedic Surgeons *

Introduction

The first report of the Committee appointed to study treatment of fractures of the neck of the femur by internal fixation was rendered at the Annual Meeting of the American Academy of Orthopaedic Surgeons at Memphis, Tennessee, January 1939.

This was really not a committee report, as all the material had been collected and analyzed by Dr. H. Earle Conwell. Subsequent to the meeting, however, a committee was appointed, consisting of Dr. Willis C. Campbell, Dr. H. Earle Conwell, Dr. Lawson Thornton, Dr. Frank D. Dickson, and Dr. Herman C. Schumm. A most critical attitude was assumed by this committee. No case reports were accepted unless all data were complete. The result of this critical attitude was that the number of cases was reduced from 1485 to 241. A report based on this relatively small number of complete cases, with accurate information, is greatly to be preferred to a report based on a large number of cases with incomplete data.

This report represents the second installment of the study of internal fixation and the treatment of acute central fractures of the neck of the femur. It is planned to have the committee continue this study so that in another two years a third report will be rendered, based on further study of this same group of cases. This future report should be most instructive, particularly with reference to aseptic necrosis and hypertrophic changes.

The Academy is indeed grateful to the Chairman of the Committee and his coworkers for this outstanding, constructive piece of work.

M. N. Smith-Petersen, M.D.

Report

In selecting the members of this Sub-Committee for the further study of internal fixation in the treatment of fresh fractures of the neck of the femur, care was taken to appoint men who were thoroughly familiar with the two methods of internal fixation in most common use, namely, the Smith-Petersen nail and multiple wires or pins. Further, in order that any personal element might be eliminated in the conclusions drawn, no man was asked to serve who had originated a particular method of treatment.

A preliminary report of 1485 cases compiled from tabulated data submitted by members of the Academy was made by Dr. H. Earle Conwell, Secretary of the Fracture Committee, at the Academy Meeting in January 1939, and published in *The Journal of Bone and Joint Surgery* (XXI, 483, April 1939). Unfortunately, that report did not constitute a true analysis of the cases according to the rules established by the present Committee, since it was not based upon an actual study of the roentgenograms and other data submitted.

For this report, the Committee has accepted only cases in which clinical and roentgenographic data were available. Opinion regarding the final results was based solely upon roentgenographic evidence; no written statements as to the status of union were considered. In addition to clinical data submitted on the tabulated forms provided by the Academy, roentgenograms were available in 923 cases. Although in a large proportion of these the roentgenograms were inadequate for study of the final results, many

* Presented at the Annual Meeting of the American Academy of Orthopaedic Surgeons, New Orleans, Louisiana, January 14, 1941.

interesting observations were made from the review of the entire group. The requirements for inclusion in the final analysis were as follows:

1. The fracture must be a complete, fresh fracture of the neck of the femur with displacement of the fragments.
2. Conclusive evidence of such a fracture must be presented, preferably by roentgenograms made prior to reduction. Without preoperative roentgenograms, the Committee was at times unable to distinguish a complete fracture of the femoral neck from an impacted fracture or a trochanteric fracture.
3. Roentgenograms must be submitted of the fracture after reduction, showing the type and position of the internal fixation employed.
4. Roentgenograms must be submitted of the fracture region one year or longer following reduction. Cases wherein final roentgenograms were made before the elapse of one year were eliminated, regardless of the status of union. A number of fractures which appeared to have united solidly in less than one year, and even after one year, have subsequently terminated in non-union. In order to eliminate error in so far as possible, one year was decided upon as a minimum follow-up period.

Because of the lack of data submitted, the number of cases which fulfilled these strict requirements was comparatively small. It was believed, however, that a study of a small number of complete cases with definite end results would be more valuable than the study of a larger series based upon less accurate data.

TABLE I

TYPES OF FIXATION EMPLOYED IN 241 COMPLETE CASES

Type of Fixation	Cases	Per Cent.
1. Smith-Petersen nails	144	59.8
2. Wires	83	34.4
3. Miscellaneous	14	5.8
Total	241	100.0

The data presented in Tables I to IV are based on the study of 241 cases wherein the criteria outlined above were fulfilled. The data contained in Tables V to VIII are based upon a study of the 923 cases.

The Smith-Petersen nails included all modifications of the three-flanged nail which were submitted to the Committee. The wires included multiple pins or wires, such as Austin Moore pins, Knowles pins, Gaenslen spikes, Kirschner wires, etc.; the majority consisted of Austin Moore pins. It was felt that the series was too small to differentiate between the various types of pins and wires. The miscellaneous group included screws, bone grafts, and other materials.

Solid bony union took place in 169, or 70.1 per cent., of the 241 accepted cases.

As stated before, only fractures wherein union was solid, as demonstrated by roentgenograms taken one year or longer after fixation was inserted, were accepted. If, in the

TABLE II

PERCENTAGE OF BONY UNION OBTAINED WITH EACH TYPE OF FIXATION

Type of Fixation	Cases	Unions	Per Cent.
1. Smith-Petersen nails	144	105	72.9
2. Wires	83	52	62.7
3. Miscellaneous	14	12	85.7
Total	241	169	70.1

TABLE III

INCIDENCE OF ARTHRITIC CHANGES FOLLOWING BONY UNION

Grade of Change	Smith-Petersen Nail		Multiple Wires	
	Cases	Per Cent.	Cases	Per Cent.
No change	77	73.4	37	71.2
Grade I	3	2.9	5	9.6
Grade II	5	4.7	2	3.8
Grade III	5	4.7	1	1.9
Grade IV	15	14.3	7	13.5
Total	105	100.0	52	100.0

opinion of the Committee, union was doubtful, the fracture was regarded as ununited. It is probable that some of those thus excluded will ultimately firmly unite. The 70.1 per cent. of bony unions indicated in Table II stood the test of a hypercritical committee and the handicaps associated with the development of a new method. It should be borne in mind that the proper insertion of fixation material for fractures of the neck of the femur requires skill and experience. This series included many of the earliest cases in which internal fixation was used; without doubt, therefore, in the hands of experienced surgeons, a higher percentage of bony unions may be expected in patients being treated at the present time.

The arthritic changes observed in the head were graded as follows: Slight arthritic changes not present in the original roentgenograms, but apparent one year or longer following reduction were considered Grade I; moderately advanced arthritic changes without deformity of the head were classified as Grade II; arthritic changes associated with flattening and definite changes in the contour of the head were classified as Grade III; and extensive arthritic changes associated with disintegration of the head were considered Grade IV.

The more severe arthritic changes, Grades III and IV, were observed eighteen months to two years following internal fixation. Severe changes with disintegration of the head of the femur (Grade IV) were usually associated with aseptic necrosis of the femoral head, as indicated by an increase in density in the roentgenograms. In two cases there was a marked enlargement and irregularity of the femoral head and neck. This may have been the result of an unusual proliferative reaction of the bone to metal, or may have been some other type of pathological process.

TABLE IV

THE RELATION OF REDUCTION TO UNION

Reduction	Total		Union		Non-Union	
	Cases	Per Cent.	Cases	Per Cent.	Cases	Per Cent.
Good	173	71.8	132	76.3	41	23.7
Fair	44	18.2	26	59.1	18	40.9
Poor	24	10.0	11	45.8	13	54.2
Total	241	100.0	169	70.1	72	29.9

Anatomical replacement of the fragments or a slight valgus position was regarded as a good reduction, apposition of 75 per cent or more of the fractured surface of the neck with the corresponding fractured surface of the head, with only slight or moderate rotation of the head, was considered a fair reduction. Apposition of less than 75 per cent of the two fractured surfaces, or marked rotation of the head, or appreciable coxa vara, or a combination of these conditions, was considered a poor reduction.

The foregoing statistics are based upon the 241 complete cases. An additional study was made of the 682 cases in which roentgenographic and clinical data were insufficient to permit their inclusion in the final analysis. The following facts were obtained from a review of the entire series of 923 cases.

In the total of 923 cases, there were 107 deaths, or a total mortality of 11.6 per cent. In ninety cases, reduction and nailing were carried out in conjunction with an arthrotomy. Among these, there were nine deaths, a mortality of 10.0 per cent. The fixation was inserted without opening the hip joint in 600 cases; in this group there were sixty-nine deaths, a mortality of 11.5 per cent. In 107 cases the method of fixation was not stated; among these there were twenty-three deaths, a mortality of 21.5 per cent. The above data appear to indicate that an arthrotomy or open reduction does not increase the mortality. This, however, is probably not true. The patients upon whom an arthrotomy was done were principally private patients, whereas a large proportion of those whose fracture was fixed without arthrotomy were reported from city hospitals, and some of them from insane asylums. The general medical condition of the latter types of patients is poorer and the postoperative care inferior to that of private patients.

Of the 923 cases, 126 were rejected because the fractures were trochanteric in type, or the condition was a slipped upper femoral epiphysis rather than a fracture, or because of meager roentgenographic data. The following statistics were based upon the remaining 797 cases:

TABLE V

TYPE OF FIXATION EMPLOYED

	Type of Fixation	Cases	Per Cent
1	Smith-Petersen nails	572	71.8
2	Wires	162	20.3
3	Miscellaneous	63	7.9
Total		797	100.0

TABLE VI

FAILURE TO MAINTAIN REDUCTION

		Cases	Failures	Per Cent
1	Smith-Petersen nails	572	63	11.0
2	Wires	162	34	21.0
3	Miscellaneous	63	13	20.6

A study was made to determine the efficiency of the fixative agent in maintaining the reduction of the fracture, whether or not the fixative agent broke, and the incidence of migration of the fixative agent either toward the acetabulum (intrusion), or toward the greater trochanter (extrusion).

Of the two cases in which the Smith-Petersen nail broke, reduction was maintained in one and lost in the other. One or more wires were broken in twenty-eight of the 162 cases in which they were used. Reduction was lost in twelve of these and was held in

TABLE VII

INCIDENCE OF BREAKAGE OF FIXATIVE AGENT

	Cases	Broken	Per Cent.
1. Smith-Petersen nails	572	2	0.35
2. Wires	162	28	17.3
3. Miscellaneous	63	2	3.2

TABLE VIII

MIGRATION OF THE FIXATIVE AGENT

	Cases	Migration	Per Cent.
1. Smith-Petersen nails	572	75	13.1
(a) Intrusion—29 (38.7 per cent.)			
(b) Extrusion—46 (61.3 per cent.)			
2. Wires	162	45	27.8
(a) Intrusion—29 (64.4 per cent.)			
(b) Extrusion—16 (35.6 per cent.)			

the remaining sixteen. Reduction was lost in both cases of the miscellaneous group in which the fixative agent broke.

Intrusion of either the Smith-Petersen nail or a wire to the point of contact with the acetabulum will result in erosion of cartilage and bone, thus leading to arthritic changes in the acetabulum. Marked erosion of bone was observed about wires which had migrated into the acetabulum. A single migrating wire tends to penetrate deeper into the acetabular floor than the larger Smith-Petersen nail. Extrusion of the Smith-Petersen nail sufficiently to lose its hold in the capital fragment will result in loss of reduction. Extrusion of the wires may or may not result in loss of fixation, depending upon the extent of extrusion and the number of wires involved. The tendency to migration of the wires was approximately twice that of the Smith-Petersen nails. The incidence of extrusion of the Smith-Petersen nails was approximately twice that of intrusion, whereas the incidence of intrusion of the wires was approximately twice that of extrusion.

It is the opinion of this Committee that, in the hands of experienced surgeons, the end results obtained in fractures of the neck of the femur have been greatly improved by the use of internal fixation. When employed by the inexperienced or untrained, the outcome is often deplorable and the end results inferior to those seen following non-operative methods.

Respectfully submitted,

WILLIS C. CAMPBELL, M.D., *Chairman*
H. EARLE CONWELL, M.D., *Secretary*
LAWSON THORNTON, M.D.
FRANK D. DICKSON, M.D.
HERMAN C. SCHUMM, M.D.

News Notes

The Fifty-Fifth Annual Meeting of **The American Orthopaedic Association** will be held in Toronto, Ontario, June 9, 10, 11, and 12, at the Hart House and the Royal York Hotel. Dr. D. E. Robertson, President, is in charge of the meeting, and careful plans have been made for the entertainment of the members and guests.

A clinical program will be presented *on* Monday and Tuesday *morning by local* surgeons.

At the session on Wednesday afternoon there will be a symposium on subjects related to the War. The scientific program is not yet completed, but copies will be mailed to members in the near future.

At the examination of the **American Board of Orthopaedic Surgery** held in New Orleans on January 11 and 12, 1941, forty-two candidates were examined and certificates were granted to twenty-eight.

The examination fees have been adjusted so as to be in closer accord with those of other specialty boards. A fee of $50.00 will accompany the application and cover the expenses of the first examination. Candidates who have to appear before the Board at second and third examinations will be charged additional fees of $25.00 for each examination following the first. This change took effect as of January 15, 1941, and is not retroactive.

The personnel of the Board at present is:

Dr. Fremont A. Chandler, Chicago, Illinois, *President.*
Dr. John C. Wilson, Los Angeles, California, *Vice-President.*
Dr. Guy A. Caldwell, New Orleans, Louisiana, *Secretary-Treasurer.*
Dr. George E. Bennett, Baltimore, Maryland
Dr. Frank D. Dickson, Kansas City, Missouri.
Dr. Melvin S. Henderson, Rochester, Minnesota.
Dr. Samuel Kleinberg, New York, N. Y.
Dr. J. S. Speed, Memphis, Tennessee.
Dr. Philip D. Wilson, New York, N. Y.

The American Physiotherapy Association will hold its Twentieth Annual Convention at Asilomar, California, July 13 to 18, 1941.

Dr. Ralph M. Carter announces the association with him of Dr. S. S. Houkom. Their office is located at 607–610 Bellin Building, Green Bay, Wisconsin.

Dr. Donald C. Durman announces the association with him of Dr. Harold E. Mayne and the opening of a new office at 408 South Jefferson Avenue, Saginaw, Michigan.

The **American Academy of Physical Medicine** will hold its Nineteenth Annual Meeting and Scientific Session on April 28, 29, and 30, 1941, in New York, with headquarters at the Hotel Pennsylvania.

The Seventieth Annual Meeting of the **American Public Health Association** will be held at Atlantic City, New Jersey, October 14, 15, 16, and 17. Headquarters for the meeting will be the Convention Hall, and residence headquarters will be the Hotel Traymore.

The **International College of Surgeons**, of which Dr. Fred H. Albee is President, will hold its Fifth International Assembly in Mexico City, August 10 to 14, 1941, in response to the invitation of the Mexican Government. With the assembly will be scientific exhibits of the latest advances in surgery, and commercial demonstrations of the newest equipment. Information about the meeting may be obtained from Dr. Max Thorek, Executive Secretary, 850 West Irving Park Boulevard, Chicago.

At the Annual Founder's Day Dinner of the Kappa Sigma fraternity, in Washington, D. C., on December 10, Dr. Fred H. Albee, President of the International College of Surgeons, was presented with a bronze plaque. The presentation was made by Senator Warren R. Austin of Vermont. The award was made in recognition of Dr. Albee's services as Chairman of the New Jersey Rehabilitation Commission, which he helped establish, and for his outstanding achievement in orthopaedic surgery.

The First Annual Medical Meeting of **The National Foundation for Infantile Paralysis** was held at the Waldorf-Astoria Hotel, New York, N. Y., on November 7 and 8, 1940. Attending the meeting were the members of the medical advisory committees, the grantees of the Foundation, and the Board of Trustees. Reports of the activities of committees and grantees for the preceding year were presented, and recommendations were made for grants for 1940–1941.

The Foundation is concerned with promotion and furtherance of research on all phases of infantile paralysis. Studies are being carried on through grants from the Foundation on problems of epidemiology, virus research, relationship of nutrition to poliomyelitis, and the prevention and treatment of the disease. In addition, a program of professional and lay education has been promoted.

The following chairmen of medical committees were appointed:

Committee on Virus Research: Dr. Thomas M. Rivers, New York, N. Y.
Committee on Research for the Prevention and Treatment of After-Effects: Dr. Philip Lewin, Chicago, Illinois.
Committee on Nutritional Research: Dr. James S. McLester, Birmingham, Alabama.
Committee on Epidemics and Public Health: Dr. Herman N. Bundesen, Chicago, Illinois.
Committee on Education: Dr. Max M. Peet, Ann Arbor, Michigan.
Committee on Medical Publications: Dr. Morris Fishbein, Chicago, Illinois.

The Annual Meeting of the **British Orthopaedic Association**, originally scheduled for October 25 and 26, was held in Oxford on January 3, under the Presidency of Prof. T. P. McMurray.

The program included the following papers:

Late Results of Fractured Necks of Femur—Mr. A. L. Eyre-Brooke and Mr. K. H. Pridie.
Nerve Regeneration and Nerve Grafting—Mr. J. L. Young.
The Indications for Excision of the Patella—Mr. Norman Roberts.
The Correction of Scoliosis—Mr. G. E. Thomas.
Treatment of Fractures of the External Tuberosity of the Tibia—Mr. W. S. Diggle.
The Result of Radical Treatment in Diseases and Injuries of the Carpal Semilunar—Mr. F. C. Dwyer.
Treatment of Compound Fractures of the Leg—Mr. G. K. McKee.
The Organization of Orthopaedics in the R.A.F.—Mr. R. Watson-Jones.

Prof. H. J. Seddon was elected Honorary Secretary, succeeding Mr. E. P. Brockman.

The following were elected to Associate Membership:

Mr. James Rowan Armstrong.
Mr. Andrew L. Butler.

Mr. Ian Lawson Dick.
Mr. Erwin Flatow.
Mr. Edward John Gallagher.
Mr. Ronald Neville Houlding.
Mr. G. A. Nicholl.
Mr. Archibald Ronald.
Mr. Nicholas Vere-Hodge.
Dr. G. F. Pennell (Toronto, Ontario, Canada).

The following Honorary Member was elected:

Dr. José Trueta.

THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

The Ninth Annual Convention of The American Academy of Orthopaedic Surgeons was held at the Hotel Roosevelt, New Orleans, January 12, 13, 14, 15, and 16, 1941, under the Presidency of Dr. Robert D. Schrock. The attendance was larger than at any previous meeting.

On the morning of January 13, a clinical program was presented at Tulane Medical School, with an address of welcome by Dean Maxwell E. Lapham. The afternoon of this day was free for the delegates to visit the scientific exhibits, which throughout the meeting were an outstanding feature.

The scientific program was presented at the sessions on Tuesday, Wednesday, and Thursday, and included the following papers:

Tuesday, January 14

Morning Session

Localized Fibrocystic Disease of Bone—Dr. Rufus H. Alldredge, New Orleans, Louisiana.

Aseptic Necrosis and Bone Drilling—Dr. Ernst Bergmann and Dr. Arthur H. Krida, New York, N. Y.

Operative Treatment of Legg-Perthes Disease—Dr. Paul B. Steele, Pittsburgh, Pennsylvania.

Thrombophlebitis and Postphlebitic Oedema—Dr. Alton Ochsner, New Orleans, Louisiana.

Congenital Pseudarthrosis—Dr. Harold B. Boyd, Memphis, Tennessee.

Shelf Operation at the Hip: New Method—Dr. Edwin W. Ryerson, Chicago, Illinois.

An Evaluation of Physiotherapy in Early Treatment of Anterior Poliomyelitis—Dr. H. R. McCarroll and Dr. C. H. Crego, Jr., St. Louis, Missouri.

Afternoon Session

Bone Tumors in Reference to Their Radio Sensitivity—Dr. Murray M. Copeland, Baltimore, Maryland.

Gradation of Ewing's Tumors—Dr. Willis C. Campbell and Dr. J. F. Hamilton, Memphis, Tennessee.

Hemangioma of the Vertebra—Dr. R. K. Ghormley and Dr. A. W. Adson, Rochester, Minnesota.

End Results of 200 Cases of Suppurative Arthritis—Dr. John A. Heberling, Pittsburgh, Pennsylvania.

The Use of Neo-Arsphenamine in the Treatment of Acute Osteomyelitis with Associated Staphylococcus Septicaemia: A Clinical and Experimental Study—Dr. Edward LeCocq, Seattle, Washington.

Wednesday, January 15

Morning Session

An Accurate Method for the Estimation of the Expected Growth of the Femur and Tibia in Individual Children—Dr. Gerald G. Gill, San Francisco, California.

A Study of End Results in Bone Lengthening—Dr. Beveridge H. Moore, Chicago, Illinois.
The Timing of Fracture Healing Process: Its Influence on Choice and Application of Treatment Methods—Dr. Clay Ray Murray, New York, N. Y.
Treatment of Osteomyelitis with Sulfathiazole Used Systemically and Locally—Dr. Frank D. Dickson, Dr. Rex L. Diveley, and Dr. Richard Kiene, Kansas City, Missouri.
The Fate of Fascia Lata in Knee-Joint Reconstruction (Histological Study)—Dr. E. T. Evans, Minneapolis, Minnesota.
Comparison of Stainless Steel and Vitallium as Material for Internal Fixation of Bone—Dr. J. Albert Key, St. Louis, Missouri.
Use of Vitallium Ferrule to Alleviate Lesions of the Head of the Radius—Dr. Kellogg Speed, Chicago, Illinois.
Fracture of the Patella Treated by Removal of the Fragments: End Results—Dr. J. E. M. Thomson, Lincoln, Nebraska.
Some Mechanical Derangements of the Knee—Dr. Allen F. Voshell and Dr. Otto C. Brantigan, Baltimore, Maryland.

Afternoon Session

Organization for Evacuation and Treatment of War Casualties—Col. N. T. Kirk, Washington, D. C.
President's Address—Dr. Robert D. Schrock, Omaha, Nebraska.
Conservative and Operative Treatment of Fractures of the Carpal Scaphoid—Dr. Keene O. Haldeman and Dr. Ralph Soto-Hall, San Francisco, California.
Use of Preserved Bone Grafts in Orthopaedic Surgery—Dr. Alberto Inclán, Havana, Cuba.
Treatment of Calcified Tendinitis—Dr. Joseph E. Milgram, Brooklyn, New York.
The Public Care of the Physically Handicapped—Dr. Fred H. Albee, New York, N. Y.

THURSDAY, JANUARY 16

Morning Session

The Rib Joints—Dr. Joel E. Goldthwait, Boston, Massachusetts.
The Rôle of Curare in the Prevention of Fractures in Convulsive Metrazol and Insulin-Shock Therapy—Dr. W. R. Hamsa, Omaha, Nebraska.
Experimental Studies in the Use of a U Clamp for Approximation and Fixation of Spinous Processes in Vertebral Fractures—Dr. Robert V. Funsten, Charlottesville, Virginia.
Surgery of the Intrinsic Muscles of the Hand Other Than Those of Opposition of the Thumb—Dr. Sterling Bunnell, San Francisco, California.
A New Operation for Acromio-Clavicular Dislocation—Dr. E. B. Mumford, Indianapolis, Indiana.

On Wednesday evening, January 15, the annual banquet was held at the Hotel Roosevelt. After the banquet, prizes were awarded by the Committee on Scientific Investigation for the Scientific Exhibits, as follows:

Gold medal to Dr. Clay Ray Murray and Dr. Stephen Hudack, for Originality of Presentation and Research. Their exhibit was entitled "Operative Fixation of Long-Bone Fractures".

Gold medal to Dr. Carl E. Badgley and Dr. George Hammond, for Scientific Information, as shown by their exhibit on "Suppurative Hip-Joint Disease".

Gold medal to Dr. Allen F. Voshell and Dr. Otto C. Brantigan, for the Clinical Value of their exhibit, "Internal Derangements of the Knee—Anatomical Demonstrations".

Certificates of Honorable Mention were awarded to the following for their exhibits:

Dr. Vernon L. Hart—Congenital Hip Without Dislocation.

Dr. Paul B. Steele—New Operative Treatment for Perthes' Disease.
Dr. Paul C. Colonna and Dr. Denman C. Hucherson—A Survey of Paralytic Scoliosis in Oklahoma.
Dr. Lenox D. Baker and Dr. Alfred R. Shands—Gross Pathology of Bone.
Dr. Guy A. Caldwell and Dr. Rufus H. Alldredge—Tibiofibular Diastasis and Associated Lesions.
Dr. Willis C. Campbell and Dr. Harold B. Boyd—Treatment of Fracture of the Ulna with Dislocation of the Head of the Radius.

Executive Sessions were held on Tuesday at noon and on Thursday morning. The new officers and the following members of committees were elected:

Membership Committee: Dr. Mather Cleveland, New York, N. Y.
Program Committee: Dr. James E. M. Thomson, Lincoln, Nebraska.
Committee on Scientific Investigation: Dr. G. E. Haggart, Boston, Massachusetts.
Committee on Legislation and Medical Economics: Dr. A. Bruce Gill, Philadelphia, Pennsylvania.
Representatives chosen for the American Board of Orthopaedic Surgery:
Dr. Joseph A. Freiberg, Cincinnati, Ohio, and Dr. Edward L. Compere, Chicago, Illinois.

Dr. Henry W. Meyerding, Rochester, Minnesota, was elected Representative of the Academy on the Board of Governors of the American College of Surgeons.

The Membership Committee announced the election of the following new members:

Dr. Lenox D. Baker, Durham, North Carolina.
Dr. Charles H. Baldwin, Utica, New York.
Dr. William H. Barker, Houston, Texas.
Dr. Harold B. Boyd, Memphis, Tennessee.
Dr. Louis W. Breck, El Paso, Texas.
Dr. Norman R. Brown, Spokane, Washington.
Dr. Wilfred S. Clark, Ventura, California.
Dr. John R. Cobb, New York, N. Y.
Dr. Harold H. Cohen, New York, N. Y.
Dr. James Pierce Cole, Buffalo, New York.
Dr. Malcolm B. Coutts, New York, N. Y.
Dr. Henry B. Crawford, Rochester, New York.
Dr. Edward H. Crosby, Hartford, Connecticut.
Dr. Clyde W. Dawson, Columbus, Ohio.
Dr. Otto A. Engh, Washington, D. C.
Dr. Louis A. Goldstein, Rochester, New York.
Dr. William T. Green, Boston, Massachusetts.
Dr. Benjamin B. Greenberg, New York, N. Y.
Dr. Edward J. Haboush, New York, N. Y.
Dr. Pinckney Harral, San Francisco, California.
Dr. Herbert W. Harris, Ann Arbor, Michigan.
Dr. Thomas Horwitz, Philadelphia, Pennsylvania.
Dr. Gilbert T. Hyatt, Fall River, Massachusetts.
Dr. Charles Edwin Irwin, Warm Springs, Georgia.
Dr. Frank S. Jones, Hartford, Connecticut.
Dr. Walter W. King, Peoria, Illinois.
Dr. Julius Kreitman, Brooklyn, New York.
Dr. Robert F. Legge, Oakland, California.
Dr. Max A. Levine, Los Angeles, California.
Dr. Herman S. Lieberman, New York, N. Y.
Dr. Frederick L. Liebolt, New York, N. Y.
Dr. Paul H. Martin, Jacksonville, Florida.
Dr. Robert Mazet, Jr., Great Neck, New York.

Dr. James McAteer, New York, N. Y.
Dr. H. Relton McCarroll, St. Louis, Missouri.
Dr. William D. McElroy, Youngstown, Ohio.
Dr. Donald S. Miller, Chicago, Illinois.
Dr. Ernest E. Myers, New York, N. Y.
Dr. Benjamin E. Obletz, Buffalo, New York.
Dr. Carson R. Reed, Jr., Shreveport, Louisiana.
Dr. Ward N. Rolland, Los Angeles, California.
Dr. Albert J. Schein, New York, N. Y.
Dr. Charles E. Sevier, Denver, Colorado.
Dr. John A. Siegling, Urbana, Illinois.
Dr. Frank A. Slowick, Pittsfield, Massachusetts.
Dr. Edward T. Smith, Houston, Texas.
Dr. Harry A. Smith, Wilkes-Barre, Pennsylvania.
Dr. Milton Strong Thompson, Portland, Maine.
Dr. Pedro Sanchez Toledo, Havana, Cuba.
Dr. James T. Tucker, Richmond, Virginia.
Dr. J. Irving Tuell, Seattle, Washington.
Dr. Raymond M. Wallerius, Sacramento, California.

The officers for the ensuing year are:

President: Dr. Oscar L. Miller, Charlotte, North Carolina.
President-Elect: Dr. Carl E. Badgley, Ann Arbor, Michigan.
Vice-President: Dr. Herman D. Schumm, Milwaukee, Wisconsin.
Treasurer: Dr. E. Bishop Mumford, Indianapolis, Indiana.
Secretary: Dr. Rex L. Diveley, Kansas City, Missouri.
Librarian-Historian: Dr. Philip Lewin, Chicago, Illinois.

The next meeting will be held in Washington, D. C., January 11 to 15, 1942. Dr. Guy W. Leadbetter, of Washington, was appointed chairman of the Local Arrangements Committee.

Current Literature

Die normale und gestörte Knochenbruchheilung (Normal and Pathological Fracture Healing). Dr. Werner Block. Stuttgart, Ferdinand Enke, 1940. 49 marks.

The present volume constitutes the sixty-second in the series of *Neue Deutsche Chirurgie* originally begun by von Bruns and continued under the editorship of Sauerbruch. For those interested in the healing of fractures, this book is of the utmost importance. As its title may be translated, it is not only a study of normal and pathological fracture healing, but also a study of the healing of fractures in normal and pathological bones. Indeed, more than this, it is a review, on a broad biological basis, of all the processes which lead to the development of bone.

The first section of the work is devoted to a rapid historical review of the various theories of fracture healing. Since this involves an evaluation of the importance of the different components of bone healing, the next eighty pages are dedicated to a consideration of the rôle of the periosteum, the marrow, the bone lamellae, the connective tissue, the muscles, the reticulo-endothelial system, the blood vessels, and hemorrhage, as well as the nerve tissue, in the mechanism of fracture healing. All of the evidence, both for and against any particular point of view, is presented with a singularly impartial and critical attitude, even though the personal preferences of the author are presented in short summaries.

In logical sequence, the peculiarities of healing in special types of fractures—for example, epiphyseal fractures, joint fractures, and fractures of the long and flat bones—are considered. The influence on healing of treatment by means of plaster, of traction, and of open operation is discussed. Despite the fact that the author is clearly in favor of the method of balanced traction, the opinions of proponents of other methods are clearly presented.

The chapters devoted to the explanation of the physics, the physical chemistry, the colloid chemistry, and the chemistry of fracture healing are among the most interesting and stimulating in the entire volume. Though the significance of the mechanical and physico-chemical influences are clearly delineated, the author frankly admits that some additional force, a "nisus formativus"—the old "vitalismus"—must be invoked to explain the fundamental problems, for which not even the newer knowledge of diet, vitamins, and hormones suffices.

In general, the normal appearance of bone is considered as a manifestation of normal differentiation in young mesenchymal tissues. The pathological manifestations are to be considered merely as an interference with the normal course of differentiation. It is in this light that the whole interesting chapter on pseudo-arthroses and the final chapter on fracture healing in diseased bone are approached.

All in all, this book is one of the most fascinating that has fallen to the lot of this reviewer. Not only is it a repository of much important and scattered data; it is a rich storehouse of bibliographical references and a perfect mine in which unending problems for further research lie exposed to the mind of those who are interested. The book would well repay translation for those who cannot read German, and is a "must" for those who can master the language difficulty.

Diagnosis and Treatment of Arthritis and Allied Disorders. H. M. Margolis, M.D., F.A.C.P. New York, Paul B. Hoeber, Inc., 1940. $7.50.

General practitioners and medical students will obtain from this book a much better understanding of the many problems of "rheumatism" and arthritis as well as valuable information concerning the diagnosis and treatment of individual patients. The author strives particularly to dispel the attitude of defeatism which prevails among many general

practitioners responsible for the treatment of patients with arthritis. Poor therapeutic results, upon which the existence of this attitude depends, are due in part to errors in diagnosis and failure to prescribe appropriate therapy.

The classification of the arthritides is simple and workable. Nearly half of the book is devoted to atrophic or rheumatoid arthritis. Many readers will wish that the sections on hypertrophic arthritis, rheumatic fever, and the specific infectious arthritides had been presented in more detail. Even less space is allotted to traumatic arthritis, hemophilic arthritis, the arthritis of serum sickness, neuropathic joint disease, fibrositis, Dupuytren's contractures, and miscellaneous rheumatic conditions. Such brevity is unfortunate in that information often required by the practitioner has been omitted. A much larger section is devoted to pain in the shoulder and arm, subacromial bursitis, periarthritis of the shoulder, cervical rib, the scalenus anterior syndrome, and various types of nerve involvement. The last hundred-odd pages contain a comprehensive discussion of low-back and sciatic pain. The sections on pain in the shoulder, arm, and low back are of value principally from the point of view of differential diagnosis. The importance of considering "sciatica" as a symptom, rather than a diagnosis, is well brought out. Each chapter concludes with a bibliography, which in general is well selected.

The chapters dealing with the constitutional background and etiology of rheumatoid arthritis are highly speculative. The author's opinions are traditional, though he is generally careful to qualify statements for which direct proof cannot be given. It is admitted, for instance, that the conclusion that focal infections play a definite rôle in the etiology of rheumatoid arthritis is based solely on clinical impressions.

The clinical and roentgenographic descriptions of rheumatoid arthritis are detailed. There is no mention of eye lesions which represent a rare, yet sometimes the first, manifestation of this constitutional disease. There is a brief discussion of the sedimentation rate in which it is stated that corrections for anaemia are unnecessary. The author fails to refer to literature which upholds the opposite point of view. The importance of this point lies in the fact that certain patients with anaemia will be considered to have elevated sedimentation rates unless the corrections are taken into account.

For the general practitioner, the chapters on the treatment of rheumatoid arthritis should prove to be the most valuable in the book. Those dealing with the prevention and correction of deformities contain information seldom taught in medical schools or on the medical wards of hospitals. These chapters are well illustrated and the author's recommendations are logically presented. In the chapter on physical therapy, stress is correctly placed upon simple and effective methods of treatment which the patient or his family can carry out at home. Although the author describes in detail the technique of roentgen-ray therapy, he admits that its value remains to be proved. Concerning the value of gold as an adjunct in the treatment of rheumatoid arthritis, the author is hopeful, but not completely convinced. Since clinical data relative to the effectiveness of gold are still incomplete, this opinion is shared by many others in this country. The use of colloidal sulphur, vaccines, fever therapy, foreign-protein therapy, or bee venom in the treatment of rheumatoid arthritis is not recommended.

Die angeborene Hüftverrenkung als orthopädisch-geburtshilfliches Problem (Congenital Dislocation of the Hip as an Orthopaedic-Obstetrical Problem). *Hans* Storck. (Beilageheft zur *Zeitschrift für Orthopädie*, LXX.) Stuttgart, Ferdinand Enke, 1940. 11 marks.

A study of the etiology of congenital dislocation of the hip must include a consideration of the frequent association of scoliosis, breech presentation, torticollis, and dislocation of the knee. These all point to the presence of a mechanical factor which is the restricted space in the uterus. The usual manifestation is the abnormal position of the foetus,—breech presentation in half of the cases of wry-neck, and in one-fifth of all cases of congenital dislocation of the hip. Obstetrical abnormalities must be considered as pri-

mary, and orthopaedic deformities as secondary. Breech presentations are commonly associated with cranial asymmetry, less frequently with true torticollis, and with some disturbance of the formation of the hip joint. The associated orthopaedic deformities must be due in some cases to abnormalities of intra-uterine position.

The hereditary nature of these deformities is explained by hereditary mechanical abnormalities of intra-uterine position. This probability is based upon the frequent association of hip dislocation and torticollis with breech presentation, as proved by statistics.

CLINICAL PELLAGRA. Seale Harris, M.D., and Seale Harris, Jr., M.D. St. Louis, C. V. Mosby Co., 1941. $7.00.

This monograph is based on the personal views and experiences of a southern physician who has observed pellagra since the days when this disease was first generally recognized in the southern states. As an historical account, it is of interest because it deals at length with the many earlier beliefs and hypotheses concerning the etiology of pellagra. Some of these hypotheses, the author feels, are still worthy of serious consideration, since, in his view, the more recent theory of dietary deficiency does not provide a complete explanation of the causation of this disease. In describing the pathology of pellagra, the author presents certain views which are frankly based on individual opinion and cannot be said to have achieved general acceptance at the present time. This is particularly true of his views concerning the rôle of intestinal toxins and liver insufficiency in the production of the endemic disease. His clinical description of pellagra, which is accompanied by some good illustrations, should be found useful, particularly by those who wish to obtain some knowledge of the less common manifestations of the disease.

The final chapters are devoted to the discussion of the problem of pellagra prevention in the South. Almost every one working on nutritional problems will agree with the authors' emphasis on the importance of a good general diet in this connection, but some may not agree with their disapproval of providing the vitamin-B complex in the form of yeast, a therapeutic agent which they stigmatize as "this fungus".

The book contains sections by other authors, including two chapters summarizing the investigative work that has been carried out in recent years at Duke University and the University of Georgia. These chapters, written by Drs. Smith and Ruffin, and by Dr. Sydenstricker, are particularly interesting and informative.

The extensive bibliography renders the book particularly useful for reference purposes.

TREATMENT IN GENERAL PRACTICE: SURGERY (*Continued*). Articles republished from the *British Medical Journal*, Vol. IV. London, H. K. Lewis & Co., Ltd., 1940. 16 shillings net.

Between 1936 and 1938, three volumes were published under the title, "Treatment in General Practice". The first two dealt with some of the major medical disorders, the third with anaesthesia and surgery in general practice. This fourth volume contains articles which have appeared in the *British Medical Journal* since 1938. This volume, with its three predecessors, gives a complete conspectus of surgery for the general practitioner, which will prove of value to him in the pursuance of his every-day work. This edition, if used alone, will serve a useful purpose, as it covers a wide range of surgical conditions.

The book appears at a time when the British surgeon's skill is being put to the acid test, as a result of the War, but surgical principles are essentially the same in war as in peace.

The volume contains 552 pages of text with 143 illustrations. The first eleven chapters deal with injuries and fractures of the shoulder joint, the upper arm, elbow, lower arm, and hand. Every major injury of importance, which might occur in the upper ex-

tremity, is covered in a systematic manner. The anatomy of the region is described, the mechanism of the fracture disclosed, and its immediate and after-care outlined. A chapter on the sulphonamide chemotherapy in surgical infections follows. Chapters on lesions in the breast, injuries to the chest and spine pursue the same general method of presentation. The treatment of joint injuries, with detailed descriptions of manipulations of difficult joints, is next taken up. Six chapters cover the field of surgery of the genito-urinary tract; five take up the lesions of the rectum and anus. Ten chapters deal with the lower extremity in a manner similar to that employed with the arm. In addition to descriptions of the fractures of the extremity, the subject of amputated stumps and artificial limbs is taken up, and the preferable amputation is emphasized. An excellent chapter deals with penetrating wounds of the joints.

These and many other subjects are covered in a methodical and clear manner. The book represents the opinions of a number of British surgeons who are authorities upon the field each has presented. In the main, the surgical principles laid down are the same the world over. The general practitioner will find this volume a valuable reference book. Here he can find quickly a clear and concise discussion of many of the surgical problems with which he is often faced.

On Albers-Schönberg's Disease (Marble Bones). S. van Creveld and N. I. Heybroek. *Acta Paediatrica* XXVII, 462, 1940.

Two cases of Albers-Schönberg disease (marble bones) are reported in detail by van Creveld and Heybroek of Amsterdam. The first case was that of a new-born female child. Pregnancy had been uneventful and birth had been normal. Enlargement of the heart to percussion led to roentgenographic examination and discovery of the disease. There was sclerosis of the entire skeleton with narrowing of the marrow spaces. The blood picture showed erythroblastemia, thrombopenia, increase in stab cells, juvenile forms, and myelocytes. The serum calcium was normal; the phosphorus and phosphatase were decreased. The child died on the ninth day. Autopsy showed a purulent meningitis, slight enlargement of the heart and spleen, and extramedullary blood formation. The bones showed a diffuse osteosclerosis with failure of resorption of cartilage in the endochondral ossification and retardation of resorption of the periosteal bone on the inner side. There were no normal blood-forming elements. Practically all of the marrow was replaced by large cells resembling reticulum cells.

The second patient, a girl of four and one-half years, was brought for roentgenographic examination because she had been blind since birth. Extensive chemical studies showed normal values for calcium, phosphorus, magnesium, and phosphatase. Fracture of the left femur occurred while the patient was under observation.

From a review of 127 cases reported, including their own, the authors conclude that the disease is congenital, but not hereditary; that bodily development is retarded, but mental development, as in their second case, is normal. There is an increased tendency to fractures, and a tendency to clubbing of the long bones; transverse bands parallel to the line of the epiphyses are common. There is no definite evidence of disturbance in any organ. Diagnosis can be made only by roentgenographic examination. The authors can suggest no possible etiology nor any therapy which favorably influences the disease.—*J. G. Kuhns, M.D., Boston, Massachusetts.*

Roentgenographic Symptoms of Meniscal Lesion in the Knee Joint. Knut Lindblom. *Acta Radiologica,* XXI, 274, 1940.

The author studied a series of seventy-four cases in which arthrography was undertaken. The arthrogram was made following an injection of nine cubic centimeters of a 35-per-cent. solution of perabrodil. The author states that an arthrographic diagnosis of meniscal lesion was made in forty-three cases, operation subsequently carried out in twenty-seven, and the arthrographic diagnosis was verified in twenty-five. The symp-

toms of meniscal lesion shown by arthrogram consisted of contrast filling of a fissure in thirty-five cases; partial defect of the meniscus in ten cases; and interposition of the soft tissues between the condyles in two cases. A number of reproductions of roentgenograms are included to demonstrate the author's criteria for making the differential diagnosis from these three conditions. In twenty-seven of the cases in which arthrography was performed, a local osteophyte formation on the surface of the tibial condyle was noted. In twenty-four of these twenty-seven cases, a meniscal lesion was observed on the same side where the osteophyte was found. As a rule, osteophytes do not appear until months or years after injury to the cartilage has occurred; but in two cases, osteophytes were found as early as three weeks after the trauma. It is the author's opinion that the presence of the local osteophyte supports the clinical diagnosis of an early meniscal lesion. "In the majority of cases confirmation as to the presence of meniscal lesion can be obtained by arthrography. For the arthrographic diagnosis, the fissures of the meniscuses are most important."—*Henry Milch, M.D., New York, N. Y.*

THE GROSS PATHOLOGY OF SPONTANEOUS BONE TUMOURS IN MICE. F. C. Pybus and E. W. Miller. *The American Journal of Cancer*, XL, 47, 1940.

These authors have studied spontaneous bone tumors in a high-incidence strain of inbred mice. Nearly 600 bone lesions were found in more than 300 mice. The femora, tibiae, and spines were the commonest sites. The types of growth were extremely varied representing all possible phases in the activity of the osteoblast, from the development of true hard bone to spindle-cell sarcoma with widely disseminated metastases.

Careful analysis is presented of the age and sex incidence, distribution of metastases, clinical symptoms and signs, and gross and roentgenographic appearance. The report is illustrated with photographs, roentgenograms, and several tables.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

THE HISTOLOGY OF SPONTANEOUS BONE TUMOURS IN MICE. F. C. Pybus and E. W. Miller. *The American Journal of Cancer*, XL, 54, 1940.

This report describes the histological appearances encountered in a study of the tumors described in the preceding abstract, and is illustrated with numerous photomicrographs. The main classes of tumors are: hard osteoma, cancellous osteoma, osteosarcoma, osteosarcoma with giant cells, and chondro-osteosarcoma. Tumors in which bone and osteoid tissue predominate are the most frequent.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

INTERNAL DERANGEMENTS OF THE KNEE JOINT. AN ANALYSIS OF ONE HUNDRED CASES WITH FOLLOW-UP STUDY. L. Kraeer Ferguson and Wesley D. Thompson. *Annals of Surgery*, CXII, 454, 1940.

This is a review of 100 patients with internal derangement of the knee joint, who were operated upon, and the follow-up results in ninety-five. The anatomy, mechanism of injury, treatment, pathology, and end results are discussed.

The mechanism of injury is similar in nearly all cases,—that is, internal torsion of the femur on the tibia with the knee partially flexed. Eighty-two cases were in males, and 52 per cent. occurred in competitive sports. Sixty-eight were operated upon before their thirtieth year.

Primary treatment was always conservative. The average time from the original injury to operation was two and a half years. In the authors' experience, any knee with true locking eventually has to be operated upon.

Sixty-five of the 100 cases showed frank injuries to the menisci themselves. All but two were injuries to the internal semilunar. Thirty-one per cent. of cases had bucket-

handle tears, and 18 per cent. had tears in the anterior portion of the cartilage. In ten cases the tears were in the middle portion, and in six, in the posterior portion, of the cartilage.

In thirteen of the patients operated upon, there was a definite looseness of the cartilage. Frequently associated with this was a definite hypertrophy of the infrapatellar fat pad. These cases presented no characteristic diagnostic symptoms. The authors recommend excision of both fat pad and cartilage. There were sixteen cases in which only hypertrophy of the fat pad was found. These patients had pain and effusion. In most cases there was a history of limitation of extension.

Results were good in four cases of injury to the anterior crucial ligaments, despite the fact that in only one was an attempt at repair made. This seems most extraordinary.

There were five cases in which osteochondritis dissecans or foreign bodies were found. The abstractor presumes that the authors use the term foreign bodies to designate cartilaginous or osteocartilaginous loose bodies. The results were good in this group.

The essential points in the plan for operation and after-care are: no special preparation of knee, spinal anaesthesia, use of a tourniquet, loose suture of synovial capsule, pressure bandage without splint, early ambulatory after-care with early weight-bearing.

The results were excellent in a very high percentage of cases.—*O. B. Bolibaugh, M.D., San Francisco, California.*

Factors Influencing the Prognosis in Osteogenic Sarcoma. Bradley L. Coley and John L. Pool. *Annals of Surgery*, CXII, 1114, 1940.

This study is based on 217 cases of osteogenic sarcoma observed at the Memorial Hospital and attempts to evaluate the factors influencing the prognosis. Microscopic confirmation was obtained for 160 of this group. Thirty-five patients, or 22 per cent., of this latter group remain free of disease five years after treatment.

The factors considered were: age, sex, interval elapsing between onset of symptoms and amputation of limb, anatomical location of tumor, biopsy, histological grading of tumor, and nature of treatment employed.

The peak of the age incidence occurs in late adolescence. The prognosis is exceedingly bad in this group, and nearly as bad in patients over forty. When the lesion is associated with Paget's disease, the prognosis is also extremely bad.

Of the 160 cases 100 were males and sixty females. The survival rate in females was 28 per cent., compared with 18 per cent. in males. The authors were unable to account for this difference.

Pathological fracture occurred in fifteen cases. In fatal cases the duration of life was halved. Early pathological fracture was seen most often in rapidly growing malignant tumors.

There was an interval of one year or more between onset of symptoms and amputation in 18 per cent. of the patients who died and in 22 per cent. of those who survived. Delay was usually due to failure to make a correct diagnosis.

The lower third of the femur is the most frequent location of the tumor, with the upper end of the tibia, the humerus, and fibula next in order of frequency. The more peripheral the site of the tumor, the better the prognosis.

The authors recommend aspiration biopsy and state that it was successful in 75 per cent. of cases in which it was attempted.

The gross pathological picture, as well as the microscopic picture, determine the malignancy of the tumor. The survival rate for low-grade malignancies was 40 per cent.; for average, 16 per cent.; and for high-grade malignancies 15 per cent.

Of the patients in whom amputation was performed through the bone primarily involved, 35 per cent. survived five years. Only 21 per cent. survived amputation by disarticulation through the joint above, and 36 per cent. survived amputation through the bone above. The authors believe that indiscriminate disarticulation of the hip joint for tumors in the lower third of the femur is not justified.

Amputation above with preoperative radiation remains the method of choice. Radiation alone was used in thirty-two cases, with only one survival.

Coley's toxins were administered in ninety-one cases, with twenty survivals. The authors feel that they are definitely indicated during post-operative period in young individuals.—*O. B. Bolibaugh, M.D., San Francisco, California.*

SACRO-ILIAC TUBERCULOSIS. H. J. Seddon. *British J. Surg.*, XXVIII, 193, 1940.

A group of 176 cases of sacro-iliac tuberculosis have been reviewed. From this study it is shown that it is a disease of young adults. In 33 per cent. of the cases an isolated lesion without sinuses was found. In 31 per cent. the lesion was still isolated, but sinuses were present. Tuberculosis elsewhere in the body was found in 36 per cent. of the group.

Abscesses formed in 72 per cent., and the pain usually subsided with the formation of the abscess. Associated lesions occurred chiefly in the lungs, joints, and lumbar spine. Variations in the severity of the disease and associated lesions were noted in different parts of the country. The commonest roentgenographic findings were erosion of the joint surfaces.

The mortality rate over a six-year period was 10 per cent. for the closed isolated lesions, 25 per cent. for the isolated lesions with sinuses, and 55 per cent. when other foci were present.

Relapses after recovery were rare and the patient was usually able to return to duty. Sinuses occasionally caused chronic invalidism. "Bony ankylosis is probably the usual end result of conservative treatment, even in the absence of secondary infection."

Conservatism should be used in the treatment. The surgical results are not encouraging. Fifty-four operations were performed on forty-nine patients. Radical excision was practiced twelve times with six successes. The Verrall type of fusion was done twenty-one times with satisfactory results in fourteen. Smith-Petersen's operation was done on fourteen patients, and the result was considered satisfactory in all but two.

Operation did not reduce the period of hospital treatment which averaged eighteen months.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

THE TREATMENT, COMPLICATIONS, AND LATE RESULTS OF ACUTE HÆMATOGENOUS OSTEOMYELITIS BASED ON A STUDY OF 500 CASES ADMITTED TO THE LONDON HOSPITAL DURING THE YEARS 1919–37. E. C. B. Butler. *British J. Surg.*, XXVIII, 261, 1940.

Two-thirds of the patients in this study were males, and the majority were under twenty years of age. The staphylococcus was the commonest organism isolated. Great emphasis is laid on quantitative blood cultures in determining the prognosis and the progress of the disease.

One-fourth of the patients had osteomyelitis of the femora, and one-third showed involvement of the tibiae. About one-half of the patients made a complete recovery, but the others had deformity, pain, discharge, or recurrent infection.

Treatment may be summarized as follows: blood culture, estimation of the antibodies, intramuscular administration of staphylococcal antitoxin, absolute rest of the affected bone, an abundant supply of fluids, and then operation which may consist of aspiration, incision of the periosteum, or incision and drilling of the bone.

After operation the bone is kept at rest in plaster. Repeated small transfusions may be used. Careful watch is kept for infection in other bones and for local arthritis.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

OBSERVATIONS ON DENTAL SEPSIS AND ITS RELATION TO DISEASES. M. D. Ananthachari. *Journal of the Indian Medical Association*, IX, 529, 1940.

The author comments wisely on the relation of oral sepsis to arthritis, peptic ulcer,

iritis, and anaemia. Recognizing the causative importance of dental infections in a wide variety of metastatic conditions, he yet counsels conservatism in the removal of teeth.—*Robert M. Green, M.D., Boston, Massachusetts.*

TRACTION LESIONS OF THE EXTERNAL POPLITEAL NERVE. Harry Platt. *The Lancet*, II, 612, 1940.

Mr. Platt further reviews and illustrates with additional cases a lesion which he described in *The Journal of Bone and Joint Surgery* in 1928. Nine examples of traction lesions of the external popliteal nerve produced by adduction injuries to the knee are reported. Of the nerve lesions, four were examples of overstretching without loss of continuity, and five were complete ruptures treated by end-to-end suture. The nerve sutures, performed after a delay of three months and longer, gave disappointing results. In traction lesions of this type, the injured nerve should, therefore, be explored within the first few weeks of the accident. In exploring the graver types of complete rupture the distal part of the nerve trunk should be sought in the region of the tear in the lateral capsule of the knee joint.—*Lenox D. Baker, M.D., Durham, North Carolina.*

STANDARD PATTERN FOR HIP SPICA. W. Sayle Creer. *The Lancet*, I, 9, Jan. 4, 1941.

The author describes a simplified method of applying a "creamed-fabric" plaster hip spica. His method is a modification of Trueta's pattern. The basic idea of the suggested modification is to use three pieces for the hip spica as in the shoulder spica. Several suggestions are offered to facilitate applying such a cast. From the number of articles appearing in the English literature on the use of patterns in applying plaster casts, the method is evidently an efficient and rapid procedure, and one which should be studied by those in America who are to have charge of such work in case of wartime or civil emergencies. To this group the article is highly recommended as it is concise and well illustrated.—*Lenox D. Baker, M.D., Durham, North Carolina.*

ALBAN KÖHLER'S DISEASE. I. N. Odesskiy and T. G. Babkin. *Novy Khirurgicheskiy Arkhiv*, XLV, 305, 1940.

The authors examined 144 normal children from three to eight years of age to establish whether this condition exists in normal children. A roentgenographic study was made and correlated with clinical and literary data. The investigation led the authors to the conclusion that Köhler's disease of the navicular bone is only a variety of normal development of the foot and does not represent a pathological entity.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

JUVENILE OSTEOCHONDROSIS. C. A. Stammel. *Radiology*, XXXV, 413, 1940.

The author gives an excellent review of the condition of osteochondritis or "osteochondrosis", as more recently suggested by Harbin, because it involves various centers of bone growth. The author points out the confusion which has come from designating the lesions in their various locations, by the names of the men who first described them, and the desirability of classifying them all as osteochondrosis. He gives good descriptions of the condition in its various locations, with its course, symptomatology, roentgenographic characteristics, and final outcome, and with excellent illustrations.—*Edward N. Reed, M.D., Santa Monica, California.*

ROENTGEN FINDINGS IN CAISSON DISEASE OF BONE, WITH CASE REPORTS. Richard A. Rendich and L. A. Harrington. *Radiology*, XXXV, 439, 1940.

The authors review the literature on caisson disease of bone, and describe four cases from their own service.

The primary lesion is an accumulation of nitrogen gas in the bone, with a resultant massive aseptic necrosis. Involvement of the articular cortex and cartilage leads to the slow development of arthritis deformans, with or without osteocartilaginous loose bodies. Medullary calcification and disturbance of the lamellar structure of the ends of the larger long bones are characteristic.—*Edward N. Reed, M.D., Santa Monica, California.*

VERTEBRA PLANA (CALVÉ) (OSTÉOCHONDRITE VERTÉBRALE INFANTILE). Bruno Valentin. *Revista Brasileira de Cirurgia*, June 1940.

The effects of vertebra plana (Calvé) have been known for about fifteen years. Previously, it had been considered a tuberculous affection of the spine, but it should be classified among the diseases due to growth disturbance, together with diseases of the head of the femur, the navicular bone, etc. The author states that there have been only about thirty cases reported in the literature, and these occurred in children from two to fourteen years of age. He then discusses the clinical picture and the roentgenographic diagnosis of the disease. Regeneration of the affected vertebrae is evident at about the time that puberty begins.

The author reports two cases. One of his patients, who showed the affection in several vertebrae, was improving but had not entirely recovered.

RECONSTITUIÇÃO ARTICULAR AUTOPLÁSTICA DO COTOVELLO VALOIÇANTE (Autoplastic Articular Reconstruction of the Flail Elbow). Achilles de Araujo. *Revista Brasileira de Orthopedia e Traumatologia*, II, 3, 1940.

The author describes a case of elbow reconstruction in which, through a posterior incision, the elbow was approached, and a new articulation created on the anterior surface of the lower end of the humerus with a posterior ledge. The author believes that subperiosteal resections of the elbow are more useful than other types of operations in cases of traumatic lesions of the elbow, whether suppurative or not. The importance of physiotherapy is indicated. In the author's series of eleven patients with flail elbow, four were treated and improved by physiotherapy alone; two were treated by open capsuloligamentous reconstructions; two were operated upon to obtain bony ankylosis; and one required an amputation.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

AN ANALYSIS OF THE TREATMENT OF SIXTY-EIGHT CASES OF FRACTURES OF THE SHAFTS OF THE TIBIA AND FIBULA WITH ROGER ANDERSON SPLINT. Howard A. Swart. *Southern Med. J.*, XXXIII, 1081, Oct. 1940.

After describing the method of using the splint in the treatment of fractures of the shafts of the tibia and fibula, the author makes a statistical analysis of the age, sex, color, and occupation of the patients; types and locations of fractures; incidence of infections; details of treatment; and results. There was slow union in 10.3 per cent. and non-union in 5.8 per cent. Open reduction was used in 3 per cent. Of the known end results 90.7 per cent. were good and 9.3 per cent. bad (non-union); 10.3 per cent. were still under observation. The average time away from work was 7.43 months. The author discusses common errors and the advantages and disadvantages of the method of treatment.—*Fred G. Hodgson, Atlanta, Georgia.*

PRACTICAL PROBLEMS OF PHYSICS IN ORTHOPEDIC SURGERY. Earl D. McBride. *Southern Med. J.*, XXXIII, 1272, Dec. 1940.

The orthopaedic surgeon must be proficient in the science of mechanics; he must be a construction engineer as well as a surgeon. The analytical study of physical disability involves more than clinical judgment and decision. The laws of physics, and mechanical demands must at least be recognized as dominating the biological laws. The forces of stress and equilibrium are accurately calculated for the construction of inanimate material. The same approach may be made to living material, even though it may not

reach perfection because of biological variations. Several examples are briefly presented here to illustrate how such information may be formulated mathematically.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

THE SURGICAL TREATMENT OF UNEQUAL LEG LENGTH. Paul H. Harmon and William M. Krigsten. *Surgery, Gynecology and Obstetrics*, LXXI, 482, 1940.

The writers discuss three methods of leg-length equalization, along with the prevention of shortening, and physiology of bone bearing on longitudinal growth disturbance. Most length discrepancies of one to five inches can be corrected by surgery.

The major causes of shortening are perforation of infection through epiphyseal lines and into joints, too long immobilization for poliomyelitis, and involvement of the epiphyses about the knee. Correct treatment of infection, poliomyelitis, and trauma will do much to reduce the incidence of inequality. Fusion of the upper femoral epiphysis causes little inequality if the patient is not immobilized too long. Unilateral lumbar ramisectomy has no consistent effect on longitudinal growth.

The three methods are: (1) operative slowing of growth, (2) shortening of the long extremity, and (3) lengthening of the short extremity. Operative slowing, the most conservative method, is done by epiphyseal arrest and has a definite field of usefulness, but is limited to the ages seven to twelve (fifteen in boys). Great care must be taken in the selection of cases and in considering the appropriate age for arrest. Operations should be done as early as possible. Growth factors need more study before real accuracy can be obtained. The operative technique of Phemister is described. One hundred and twenty patients have been operated upon with no infection or deaths.

Shortening of the long extremity is the most exact and applicable method. Several techniques are described, and that of making medullary and onlay grafts from the removed section of bone is recommended. Twenty-five of these operations have been done with excellent results in twenty-four. In one, infection developed, but later union was attained.

Lengthening of the short extremity has been done eleven times,—four times in the leg and seven times in the thigh; the results in three were unsuccessful. This is the least favored of the three methods because of technical difficulty and limitation in indications. With adequate musculature, and suitable bone (no previous osteomyelitis), equal extremity length should be obtainable. Multiple-pin methods with Z osteotomy for the leg and Compere's addition of a large tibial graft at the osteotomy site in the femur are recommended. Methods and results are illustrated by line drawings, photographs, and roentgenograms.—*Richard McGovney, M.D., Santa Barbara, California.*

FRACTURES IN THE NECK OF THE FEMUR—ACCURATE SUBCUTANEOUS FIXATION WITH SCREWS. Edwin O. Geckeler and Alfred Tuttle. *Surgery, Gynecology and Obstetrics.* LXXII, 106, Jan. 1941.

The writers describe a two-screw method of internal fixation which they have used in fifty cases since 1936. No cases of non-union occurred except in some with previously ununited fractures.

The method consists of subcutaneous insertion of two screws under fluoroscopic control through a guide and cannula apparatus. The guide prevents the screw from missing the abnormally anteverted neck. The apparatus is clearly described and illustrated. The anaesthetic is pentothal sodium. The reduction is by the Leadbetter method. The extremity is kept in wide abduction and internal rotation. The operator's hands work in a sterilized lead-covered box. The patient is mobilized within the first days following fixation. Crutches are used until roentgenographic evidence of bony union is present. The average age of these patients was seventy-three years, the average hospitalization twenty-four days, and the average operating time twenty-three minutes. There were no operative deaths and three operative failures.—*Richard McGovney, M.D., Santa Barbara, California.*

Sciatic Pain in Low-Back Derangements:

Its Incidence, Significance, and Treatment

A Symposium

PRESENTED AT THE ANNUAL MEETING OF THE

American Orthopaedic Association,

KANSAS CITY, MISSOURI,

on May 8, 1940

SCIATIC PAIN IN LOW-BACK DERANGEMENTS: ITS INCIDENCE, SIGNIFICANCE, AND TREATMENT

Introduction

BY FREMONT A. CHANDLER, M.D., CHICAGO, ILLINOIS, *Chairman*

In presenting a Symposium on "Sciatic Pain in Low-Back Derangements: Its Incidence, Significance, and Treatment", your officers and program committee have cooperated in selecting a subject which is wide in scope, is open to a multitude of interpretations in which fixed opinions of leaders of orthopaedic thought are in conflict, and is one that is slowly yielding to careful scientific study and analysis. The orthopaedic surgeon of wide experience, as represented by members of this Association, needs no review of the pitfalls of diagnosis or treatment. He readily recognizes the many potential etiological features of this symptom complex, and chooses from a wide variety of therapeutic measures in prescribing for his patient. As no panacea has been presented, the orthopaedic surgeon actively or passively follows the oscillations of the therapeutic pendulum, and, with the accumulation of experience, charts his own course of procedure in each case. Newer procedures are scrutinized, tested, and accepted or discarded.

The composite judgment of the membership of this Association expressed in a symposium on sciatic pain should constitute a balance wheel for all medical thought.

The breadth of the subject necessitates restriction of the range of discussion, so that a more thorough consideration of the orthopaedic phases may be developed. In order to focus attention on major divisions of the problem, your officers and committee have asked and have received the cooperation of the several essayists appearing on the program during the forenoon. These men have been asked to present their subjects with special relation to sciatic pain. Because of this limitation, their papers may not be as comprehensive as the titles would indicate.

During the afternoon, the symposium will be open for a thorough discussion. Several members have been requested to open discussion of the papers presented in the forenoon. They have been most cooperative in accepting these assignments.

To facilitate an orderly participation by as many members as possible, cards have been prepared for the use of those interested in taking part. The essayists will have twenty minutes for their presentations, the discussors five minutes.

ANATOMICAL VARIATIONS AND ROENTGENOGRAPHIC APPEARANCE OF THE LOW BACK IN RELATION TO SCIATIC PAIN

BY THEODORE A. WILLIS, M.D., CLEVELAND, OHIO

Except for a rare *Blitzkrieg* against a specific disease entity, progress of medical science has resulted from continuous pressure exerted on a wide front, advance salients being thrown out now here, now there, in the fields of bacteriology, parasitology, biochemistry, pathology, and physiology. In the excitement of victory undue importance has often been ascribed to local successes, and greater advance has been claimed than could be maintained.

In the campaign against low-back pain and sciatica one recalls the battles of Gynecology, Sacro-Iliac Subluxation, Postural Fault, Congenital Anomalies, Fascitis and Contractures, Spastic Pyriformis, Displaced Intervertebral Discs, Thickened Ligamenta Flava, and Narrowed Intervertebral Spaces. All of them were notable advances, but each of them, though temporarily overemphasized, was only a part of the campaign. Only time and perspective can attribute to each its relative importance in the general conflict.

The battle of Congenital Anomalies, which is to be discussed, like the others, overshot its true objective and was temporarily overpropagandized. That the reaction has not yet died out, nor the true importance of the advance been established, the writer is convinced; for one reason, because roentgenologist colleagues, who used to note in their reports all vertebral anomalies, have become negligent in this respect, and it was necessary for him to examine all the roentgenograms himself in collecting data for this discussion.

Theoretically, congenital anomalies of the lumbosacral and sacro-iliac areas of the skeleton may be of interest in the syndrome of low-back pain and sciatica either as predisposing or etiological agents, or as factors preventing recovery from these symptoms following injury. Certain anomalies weaken the anchorage of the spinal column to the pelvis. Others expose the contents of the neural foramina, particularly the last presacral nerve roots, to impingement, stress, or irritation from postural faults or disease.

It is unfortunate that the lumbosacral junction is the particular part of the human spinal column most subject to mechanical strain, and at the same time the part most often involved in anomalies and defects of development.

Two natural processes are to blame for this. First, an evolutionary shortening of the spinal columns of man and the other primates is being accomplished by inclusion in the sacrum of the last lumbar vertebra. Second, upright posture has been accomplished by hyperextension to

nearly a right angle at the lumbosacral area. The first process gives rise, in addition to numerical variation of presacral vertebrae, to the many anomalies resulting from partial sacralization of the last lumbar and partial lumbarization of the first sacral segments. These are evidenced as enlarged transverse processes articulating or impinging with the sacrum or ilia, narrow lumbosacral intervertebral spaces, sagittal-plane articular processes, and decrease in the anteroposterior diameter of the superior surface of the sacrum as compared to the inferior lumbar surface opposing it.

Lack of spinous processes, spina bifida, and interruptions in continuity of the neural arches, localized particularly at the lumbosacral level of the back, are examples of defective development of bone segments. Interruptions in the neural arch have been reported in all races of mankind, but not to the author's knowledge in human foetuses, or in the spinal column of any other vertebrate. This anomaly is, therefore, believed to be a consequence of assumption of upright posture.

The problem at hand is which, if any, of these anomalies and defects do, and which do not, play a part in the development of low-back pain with gluteal and sciatic distribution, or delay recovery from such symptoms arising from injury or disease. A brief discussion of these lesions and the ways in which they may so affect the body will be attempted.

It is doubtful whether the addition or subtraction from the spinal column of a normal presacral segment affects its stability to any appreciable extent. A longer back may be slightly more mobile, and a shorter one perhaps a little stronger.

It is doubtful whether bilateral, symmetrically enlarged transverse processes which do not impinge upon, or articulate with the sacrum or ilia weaken the sacro-iliac juncture. The claim has been made that these enlarged processes form a prominence over which the lower nerve roots are stretched, with resulting nerve irritation and sciatic pain. In a series of cases removal of these large transverse processes has been followed by relief of pain. Since processes and nerves develop simultaneously, it is improbable that they are maladjusted, but with development of lordosis or muscle spasticity the tension on the nerve or blood vessels might be increased, as in cervical-rib syndrome. Relief of sciatic pain has followed so many simple fasciotomies, however, that one is not justified in attributing the favorable postoperative reaction entirely to the removal of the enlarged transverse process.

It seems reasonable to suppose that asymmetrical anchorage of the lumbar column to the pelvis predisposes that part of the back to strains and sprains. The asymmetry may be in the size and attachment of the transverse processes or in the planes and inclinations of the articular facets. Variations of the latter particularly affect the direction and extent of lumbosacral mobility.

It is a fact that a congenitally narrow lumbosacral interspace approaching the first sacral interspace in depth, diminishes the size of the

foramina through which the last lumbar nerve roots emerge and thus increases liability of the transmitted nerves to pressure from accident, disease or lordosis. Differentiation of congenital from acquired narrowing of the intervertebral space must be difficult in most instances, but why a narrow space with increased overriding of the articular processes should be labelled backward displacement of the lumbar vertebra, or reversed spondylolisthesis, is a riddle. This diagnosis is based upon the relative position of the postero-inferior border of the last lumbar body to the posterosuperior border of the first sacral vertebra as shown by lateral roentgenograms, but the superior surface of the sacrum is so variable in form, its posterior border being either convex or concave toward the neural canal, that as a landmark it is most unreliable. This sacral surface was found of less anteroposterior diameter than the opposing lumbar in 66 per cent. of fifty skeletons examined.

The criticism, that museum material is worthless as evidence in proving the point, seems as preposterous as the basing of an opinion on the shadowgraph known as a roentgenogram without critical consideration of the parts casting the shadow.

It has been conclusively shown that in the great majority of vertebrae each lateral half of the neural arch develops from a single center of ossification. These two centers normally meet in the midline behind at about the time of birth, fuse, and develop the spinous processes. The lumbar spinous processes provide large surfaces for the attachment of the powerful ligaments and muscles that stabilize the lower back. Failure of the lower lumbar or the upper sacral spinous processes to develop therefore probably results in a less stable back. But sprain of a back is a matter of the strength of the affected individual in relation to the amount of force applied and his position when it is applied, and unfortunately the same individual cannot be tested with and without a spinous process.

As is well known, skeletal anomaly is often associated with defects of the soft tissues, particularly of nerve tissue. It is conceivable that cleft of the neural arch may well be associated with defective development of the spinal cord and its nerve roots in minor as well as major spina bifida. The author has been able to find very little information concerning neurological variations associated with the lesser degrees of spina bifida occulta. Dittrich reported a number of laminectomies done for sacral spina bifida occulta in all of which he found pathological fat, muscle, and fibrous tissue pressing or pulling on the nerve structures. Since these were found in muscular rheumatism, hematogenous osteomyelitis, and infantile paralysis as invariably as in spastic paralysis, eneuresis, dysmenorrhea, constipation, and the syndrome under discussion, one questions the importance of the pathology reported.

A lesion more definitely affecting stability of the lower back is the lateral defect of the neural arch. Hitchcock has come closest to explaining the etiology of this condition in attributing it to a fracture of one or both laminae incurred in early infancy before they are well ossified or

TABLE I

Comparison of Anomalies Found in the Present Series of Patients with Those in Previously Published Studies

Anomaly	Present Series 79 Cases No.	Present Series 79 Cases Per Cent.	Museum Skeletons 748 Cases Per Cent.	Badgley's 447 Cases Per Cent.	Hodges' and Peck's 538 * Cases Per Cent.	Williams' 400 Cases Per Cent.
No congenital anomaly	44	55 7	88 0	72 9		
Partial lumbarization or sacralization	20	25 3	6 68	9 7	14.3	15.7
Narrow lumbosacral discs	6	7 6		57 2	12.8	71 25
Laminar defects	5	6 3	4 14‡	8 1**		3 25**
Spina bifida occulta	7	8 8	1 2†	10 8		
Asymmetrical facets	11	13.9		21 9		2 0

* 353 cases had backache but no radiation.
† Last lumbar only.
** Spondylolisthesis.
‡ In another study of 1,520 skeletons, the author found 5.2 per cent. with laminar defects.

fused. The injured cartilaginous tissue fails to ossify and the anchorage of the spinal column to the sacrum depends upon fibrous union only. Hitchcock, Ferguson, and Friberg have each reported instances of this defect in which the consequent spondylolisthesis has occurred or progressed after injury.

Coexistence of the central and lateral defects of the neural arch would seem still further to affect the stability of the parts and their resistance to injury.

Muscle fatigue, in the lower back as elsewhere, gives rise to discomfort which increases as the cause of fatigue continues. As the musculature fails, more and more strain falls upon the ligaments and joint structures. These inelastic tissues gradually give way, but not without protest, and inflammatory changes occur, together with soreness, restricted mobility and pain both locally and along the distribution of the nerves that supply the affected parts.

Possible mechanisms of low-back and sciatic pain resulting from congenital skeletal anomalies are chronic muscle strain and ligament sprain, tension on, or compression of, nerve roots, and associated anomalies of nerve tissue.

Since there is no way of testing the strength and stability of a back with, and again without, the various anomalies, and since a surgical operation, or even such simple treatment as bed rest or postural exercise affects the part in different ways, proof of an etiological theory from the result of treatment is uncertain. Probably the best available evidence concerning their etiological importance is a determination of the incidence of the

various anomalies in a group of individuals suffering from low-back pain and sciatica and in a comparative group that is symptom-free.

In search of this information the records of the last 2,500 patients seen at the writer's office have been reviewed. Two hundred and twenty-nine, or 9.2 per cent., of them gave as their reasons for seeking professional advice low-back pain extending to one or both thighs or legs. It has been the writer's custom, if the etiology of the complaint seems clear and response to treatment is prompt, to spare the patient the expense of roentgenographic examination. After discarding these, and also those in whom there was proven pathology accounting for the complaint, for example: five with fascial contractures, twenty-two with arthritis, three with displaced intervertebral discs, four with ruptured and retracted ligamenta flava, three with tuberculosis, one with osteomalacea, and one with Paget's disease, there remained only seventy-nine patients or 34.5 per cent. in whose backs no definite pathological condition could be demonstrated.

Of these seventy-nine, twenty-three showed no skeletal anomalies. In twenty-one the transverse processes of the last lumbar vertebra were definitely large but made no contact with sacrum or ilia.

In twenty there was impingement, articulation, or fusion of one or both last lumbar transverse processes with the sacrum. The lumbosacral intervertebral space was definitely narrow in six. The neural arches were defective in five, in three of which spondylolisthesis had occurred. Spina bifida occulta was present in the last lumbar vertebra in two, and in the first sacral vertebra in five. Lumbosacral articular facets were in the sagittal plane in eleven,—four on the right, two on the left, and five bilateral.

Comparing these figures as far as possible with those obtained by the author from examination of 748 skeletons in the Hamann Museum, with Badgley's study of 447 patients who had low-back and sciatic pain, with the 538 control subjects of Hodges and Peck not presenting this syndrome, and with Williams' report of 400 patients with low-back and sciatic pain, Table I has been constructed.

It is found that only 56 per cent. of our small series were free from anomalies as compared to 72.9 per cent. of Badgley's. In the skeletal material only the transverse processes that actually impinged or articulated with the sacrum or ilium were recorded. There were 6.68 per cent. of these as compared with 25.3 per cent. in our series, 9.7 per cent. in Badgley's, 15.7 per cent. of Williams' and 14.3 per cent. of Hodges and Peck's controls.

The greatest divergence in the different series occurred in respect to the incidence of narrowing of intervertebral discs. The author found only 7.6 per cent. while Badgley found 57.2 per cent. and Williams 71.25 per cent. in their patients with backache. Hodges and Peck found 12.8 per cent. in their control patients. The author cannot account for this great difference. Badgley, and Hodges and Peck classified a disc as narrow if it were not more than one-half the thickness of the next preced-

ing one. Williams did not state the criterion upon which he based his diagnosis of narrowing. It was impossible of course to obtain this data from skeletal material, but Todd and Pyle, in measuring the discs in a series of cadavera found that the lumbosacral discs averaged about two millimeters more at the anterior borders than the discs next above.

The lateral neural arch defect was diagnosed about 1 to 3 per cent. more frequently in painful backs than in the dissecting-room material, except that in Williams' group of patients with painful backs it was diagnosed in 2 per cent. fewer. Diagnosis of this defect in a living patient is difficult and is much more apt to be overlooked than in a macerated skeleton.

Spina bifida occulta was present in seven or 8.8 per cent. of the author's patients, two in the last lumbar and five in the first sacral segments; and in 10.8 per cent. of those of Badgley. In the skeletal subjects it was found in the last lumbar in 1.2 per cent. Its incidence in the first sacral was not noted. This defect is easily diagnosed and the difference of incidence in skeletons, and normal and painful backs is apparently not great.

In eleven, or 13.9 per cent. of this series, and 21.9 per cent. of Badgley's, the lumbosacral articular facets were in the sagittal plane or otherwise asymmetrical. Unfortunately these were not included in the classification of skeleton variations.

There are certain discrepancies in the classifications of these groups of patients that affect their comparison. Badgley included in his group patients in whom there were pathological lesions to account for the symptoms. Hodges and Peck state that of their 538 controls 353 had backache but no referred pain. It is of course possible that the referred pain had merely not yet developed. Inclusion of these individuals (65 per cent. of their controls) affects their data to start with. Also an indefinite number of the skeletal museum subjects may have had backache with referred pain while alive.

Allowing for these differences in classification, there is still a greater incidence of anomalies in painful backs than in those free from symptoms or in the run of dissecting-room cadavera. The greatest variation in the respective series is in the incidence of narrow lumbosacral intervertebral discs, but since those of congenital origin cannot, or at least have not, been differentiated from those of pathological origin, an intelligent appraisal of their etiological relation to backache and referred pain is difficult.

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NEURO-ANATOMICAL AND PHYSIOLOGICAL ASPECTS AND SIGNIFICANCE OF SCIATICA

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Sciatica, an inclusive term which is used to describe a painful discomfort along the posterior aspect of the hip, thigh, and leg, has since ancient times baffled physicians in the matter of diagnosis and treatment. The numerous methods of treatment which have been heralded down through the ages as successful testify to the difficulties encountered in finding a therapeutic agent for this condition, which is permanent in effect. One of the reasons for such difficulties is the fact that the sciatic nerve is the longest nerve in the body, and, therefore, subjected to trauma and infection throughout its entire length.

The anatomical development of the lower extremities and the innervation of them was described by Stookey as follows:

"The morphological segmental arrangement, such as is found in the trunk musculature, is replaced in the extremities by a pleurisegmental arrangement, so that each muscle is innervated by nerves from several segments, thus necessitating the development of plexuses. . . .

"The formation of the limb plexuses and the distribution of their branches may be best understood by considering the development of the extremities, for in the development is found the explanation of the division of the spinal nerves into ventral and dorsal branches and, in general, their ultimate muscular distribution.

"In the human embryo the limb buds appear at about the third week. The cephalad pair lie opposite the lower four cervical and first thoracic vertebræ and the caudad pair opposite the lower lumbar and the first sacral. . . . Only the ventral primary division of the spinal nerves enter into the innervation of the limb bud approximately five for the upper extremity and seven for the lower, thus indicating that the limb buds are the outgrowth from a number of segments and are more closely associated with the ventral than with the dorsal surface of the body, since the ventral and not the dorsal primary divisions of the spinal nerves are associated with them. . . ."

"In the development of the lower extremity torsion and rotation of the femur, . . . take place . . . so that its preaxial border is turned medial and cephalad, its postaxial, lateral and caudad. Thus the dorsal or extensor musculature comes to lie ventral, and the ventral or flexor musculature, dorsal. . . . From an embryological standpoint it follows then that the primitive dorsal musculature, though rotated ventrally, should be innervated by the dorsal divisions of the lumbosacral plexus, and the

primitive ventral musculature, though rotated dorsally, by the ventral divisions."

Woltman has stressed the point that almost no type of pain is pathognomonic, but that a given disease may be accompanied by many kinds of pain, and that, although pain may be the only symptom manifested, much may be learned by the physician if he will inquire about the mode of onset, duration, and intensity of the pain. Pain is a subjective complaint, something that cannot be seen and cannot be palpated, and necessitates cautious interpretation of what the patient has to tell.

Pain, occurring in the distribution of the sciatic nerve, may be caused by a lesion of the spinal cord or nerve roots (especially from the fourth lumbar to the second and third sacral segments from which the sciatic nerve and its components are derived), by affections of the lumbosacral plexus, or by lesions of the sciatic nerve itself.

Pain which is more or less limited to the sciatic distribution has been observed to accompany lesions of the lumbar, thoracic, or even cervical portions of the spinal cord.

Pain caused by intramedullary lesions of the spinal cord usually can be distinguished from that caused by irritation of the posterior nerve roots and ganglia. The so-called central pains of this type are usually produced by irritation of the spinothalamic pathways. Central pain caused by lesions of the thalamus usually is not difficult to distinguish from that caused by lesions of the cord and is not definitely sciatic in nature. Such pain is rare. It is of a peculiar, irritating nature, and the patient is often unable to localize the pain accurately although it is usually felt in the arm and leg opposite the lesion. Such pain is often accompanied by dysaesthesia of a burning, boring nature. Head and Holmes believe that such pain is caused by the removal of the inhibitory control which the cerebral cortex normally exerts on the subcortical centers concerned with the perception of this form of sensation. Pain of central origin referable to lesions of the spinal cord is uncommon. When it occurs, however, it may be of a peculiar, agonizing type which is sometimes described as "aching, breaking, or piercing" and which is accompanied by dysaesthesia and various disagreeable sensations such as a sense of "burning" elicited by pinpricking and "vibratory electric-light sensation" produced by thermal or tactile stimuli. There is usually marked loss in the various forms of sensation below the level of the lesion, together with hyperactivity of the tendon reflexes with the occurrence of pyramidal tract signs below the level of the lesion. In the cervical or lumbar region there is a loss of tendon reflexes if the lesion occurs in the segments which mediate tendon reflexes from the extremities, such as the cervical or lumbar enlargements of the spinal cord. The pain of central lesions usually is not affected by coughing and sneezing and is rarely worse at night. There may be local tenderness to percussion at the site of the lesion.

Since a large number of patients suffering from sciatic pain have lesions involving the nerve roots which compose the cauda equina, an accurate knowledge of the anatomical aspects of this structure is essential.

Anatomically, the spinal cord usually terminates opposite the intervertebral disc below the first lumbar vertebra. The nerve roots forming the cauda equina (Fig. 1) consist of those which arise from the lumbar and sacral regions of the spinal cord, descend in the subarachnoid space intradurally, and are freely movable except as they approach their exits, where they are fixed. Thus it is that intraspinal lesions can displace and impinge on nerve roots without causing any motor, sensory, or reflex changes, and can produce the objective symptom of pain. It is a well-known fact that the pain of caudal tumors masquerades as low-back and sciatic pain for months and years before the tumor produces any objective neurological signs, and for the same reason protruded intervertebral discs and hypertrophied ligaments can produce pressure on nerve roots without producing any symptom except pain.

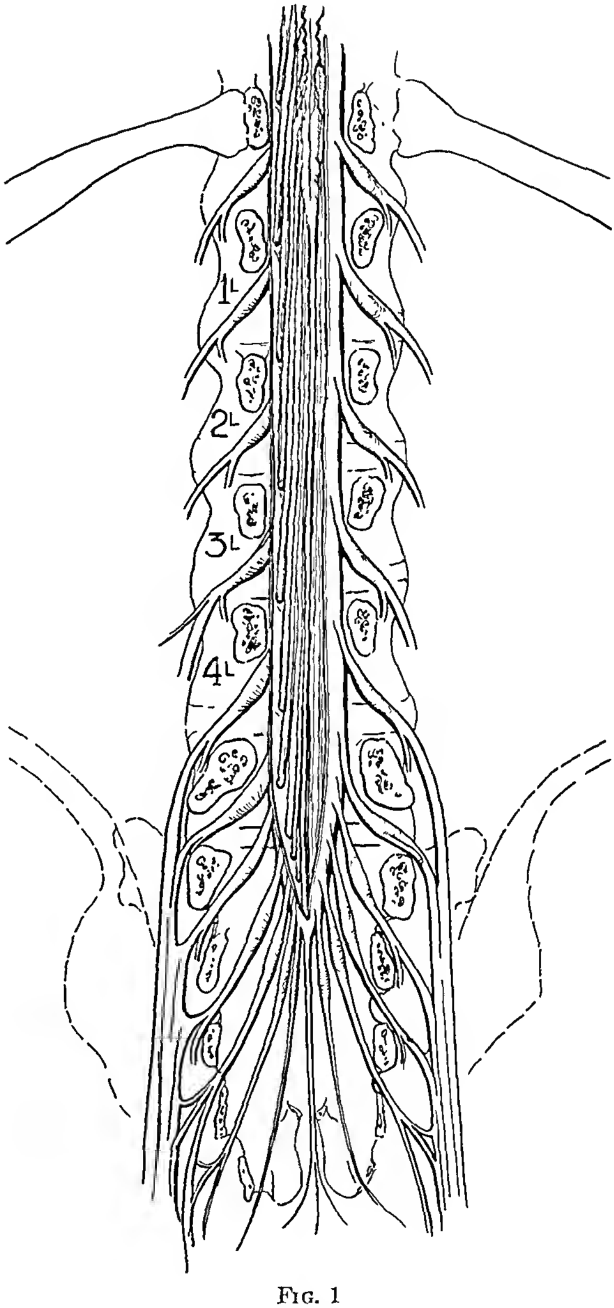

Fig. 1

Anatomical aspects of the lumbosacral region of the spinal cord with the dura open to show the relationships of the nerves to the conus medullaris.

Intraspinal lesions of the fourth and fifth lumbar or the first and second sacral nerve roots immediately after their emergence from the cord, during their course as part of the cauda equina, or in the neighborhood of the intervertebral foramina, commonly produce sciatic pain. Lesions involving or compressing these nerve roots give rise to the type of pain

known as "radicular pain". This type of pain usually is sharp, rarely aching or burning, and is often exacerbated by coughing, sneezing, or sharp flexion of the head on the chest. It tends to be worse at night, a fact which is presumably due to elongation of the spinal column while the patient is in the supine position, with resulting traction on the nerve roots. It is commonly accompanied by local tenderness to percussion over the region of the spinal column at the level of the lesion, muscular weakness, reflex changes or paraesthesia. Sensory changes, should more than one nerve root be involved, may be found, the dermatome or dermatomes affected depending on the nerve roots which are compressed. It should be emphasized, however, that all the above features need not be present to permit the diagnosis of radicular pain. In fact, it is rather rare for one patient suffering from radicular pain to demonstrate all these characteristics.

Since the spinal cord comes to an end opposite the intervertebral disc of the first lumbar vertebra, the lumbar and sacral nerve roots which compose the sciatic nerve arise opposite the twelfth thoracic and first lumbar vertebrae. Thus, extramedullary lesions at this level may produce sciatic pain of radicular type, and this is probably the highest level at which it can be obtained. Lesions at this level, however, are very likely early to involve the centers for control of the sphincter muscles, since the parasympathetic nerve supply for the urinary bladder and sphincters arises from the second and third sacral segments of the cord and the sympathetic nerve supply arises from the second to fifth lumbar segments, whereas the first to the third sacral segments mediate the control of the rectal sphincters, as well as the genital muscular system.

The recent work of Suh and Alexander on the blood supply of the spinal cord tends to indicate that the lumbar radicular vessels are important sources of blood supply for the major part of the spinal cord, whereas the middle thoracic section of the spinal cord has the poorest segmental circulation. This is of interest, since myelitic processes are more common in the latter situation. Suh and Alexander wrote, "the blood supply of the human spinal cord depends on from six to eight anterior radicular arteries, from five to eight posterior radicular arteries, from six to eleven anterior radicular veins and from five to ten posterior radicular veins, the largest always being an artery and vein in the lumbar region, the arteria and the vena radicularis magna." The arterial supply for the lumbar part of the spinal cord usually is accompanied by the second and third lumbar nerve roots, and the regions of the cord, dorsal and ventral to this, are supplied by these arterial vessels.

Because of the anatomical relationships, lesions of the nerve roots comprising the cauda equina offer special problems in diagnosis. Those lesions involving the spinal cord itself tend to produce sharply localized segmental sensory, motor, and reflex changes. This is frequently not the case when lesions involving the nerve roots in the cauda equina are present. The roots are freely movable and small lesions in the spinal canal may

cause no symptoms. The lesion may involve several nerve roots, a circumstance which confuses accurate localization. The pleurisegmental nerve supply to the muscles of the lower extremities and the tendon reflexes mediated by more than one segment of the spinal cord increase the difficulty.

One of the basic concepts in the physiology of the brain and spinal cord is that the central nervous system is organized in terms of movement patterns rather than in anatomical segments. Sherrington [20] wrote "The simplest spinal reflex, as Hughlings Jackson was wont to insist, 'thinks,' . . . in movements, not in muscles." Thus, when the foot of an animal whose brain has been destroyed is pinched, the resulting reflex is not restricted to muscles of the dermatome involved; rather, a withdrawal of the whole limb occurs. Theoretically, a segmental spinal reflex involves two elements, an afferent neuron and a motor unit. In most cases, however, the connections of the afferent neurons are such that each may excite motor units of several spinal segments through so-called internuncial neurons, to produce patterns of movement rather than contractions of specific muscles. The patellar reflex involves the second, third, and fourth lumbar nerves, and the corresponding segments in the spinal cord; the Achilles and internal hamstring reflexes, the fourth and fifth lumbar, and the first and second sacral nerves and segments, whereas the external hamstring reflex is mediated by the first, second, and third sacral nerves and segments.

The distribution in the skin of the spinal nerves forms well-defined, although overlapping, areas known as "dermatomes". Sherrington [21] pointed out that the field of each sensory root overlaps those of adjacent roots, and that section of a single root does not result in any degree of anaesthesia. He also pointed out that although in the plexuses associated with the innervation of the extremities each segmental nerve contributes sensory fibers to two or more peripheral nerves, the cutaneous distribution of these fibers is not composed of disjointed patches but forms a continuous field.

Foerster, working with patients, was able to verify and extend the work of Sherrington. He defined the dermatomes by outlining the borders of the sensibility remaining after a large number of contiguous posterior nerve roots were divided and after a single root in the middle was left intact. In addition, faradic stimulation of a distal part of a divided posterior nerve root was carried out, producing vasodilatation in the corresponding dermatome. Foerster and others believe such vasodilatation is due to the fact that the posterior roots carry efferent fibers and that stimulation of these fibers causes vasodilatation.

Foerster demonstrated that no regions of anaesthesia are found unless two or more segments are physiologically incapacitated. He further showed that lesions producing isolated segmental anaesthesia with intact segments above and below are rare, but that when they are present, they help to localize the lesion.

Therefore, it is readily seen why accurate localization of lesions in the cauda equina is extremely difficult and even, in many cases, impossible; especially is this true when posterior protrusions of the intervertebral discs produce the clinical picture of tumors of the cauda equina. At present, contrast media are usually employed to localize the lesion accurately. As knowledge of the syndrome has increased, however, it has been possible to diagnose and localize more or less accurately certain instances of protrusion of interve tebral discs, so that direct exploration is possible. Because more than 90 per cent. of instances of protruded discs occur at the fourth and fifth lumbar interspaces, it should be possible to predict the situation of the lesion among patients who have the typical syndrome of protruded intervertebral disc. Spurling and Grantham have recently stated that they were able to localize accurately posterior protrusion of a disc in the lumbar region to the exact intervertebral space in fully 50 per cent. of cases.* They give the following criteria for localization of the protrusions to the third, fourth, and fifth interspaces: At the third lumbar interspace there was found "disability of the lower part of the back, with local tenderness at the third lumbar spine and reduction of lumbar lordosis," associated with "positive Lasègue test" and "positive Naffziger test, producing paraesthesias in the fourth and fifth lumbar dermatomes". There was "reduction or absence of the knee jerk; ankle jerk unchanged", and "hypaesthesia and paraesthesias in the fourth and fifth lumbar dermatomes". At the fourth lumbar interspace there was "disability of the lower part of the back with stiffness of the lumbar portion of the spine and localized tenderness at the level of the fourth lamina, with reduction of lumbar lordosis" and "positive Lasègue test" with "positive Naffziger test with paraesthesias involving the fifth lumbar, the first sacral and perhaps the second sacral dermatomes". The ankle and knee jerks were uninvolved. "Hypaesthesia and paraesthesias [were found] in the fifth lumbar and first sacral dermatomes." At the fifth lumbar interspace there was "disability of the lower part of the back with absence of lumbar lordosis and localized tenderness to pressure over the fifth lumbar vertebrae", and "positive Lasègue test" as well as "positive Naffziger test, producing paraesthesias radiating into the first and second sacral dermatomes". There was diminution or absence of ankle jerk and "hypaesthesia involving the first and second sacral dermatomes".

However, Spurling and Grantham had only one patient suffering from a protrusion ("ruptured intervertebral disk with herniation of the nucleus pulposus") at the third interspace; thirty-nine with protrusions at the fourth and fifty-one, at the fifth interspaces. The authors' experience does not coincide with Spurling's in this regard. Their results of a

* It may be noted here that Spurling and Grantham prefer the term "rupture of the intervertebral disk" to "protruded intervertebral disk." Their explanation of such a preference is: "In order for the disk to produce symptoms we believe the annulus fibrosus must have been ruptured or torn, and, if the nucleus pulposus is extruded through the tear, a certain group of symptoms will usually appear; if the nucleus is not so extruded, however, another set of symptoms will be encountered."

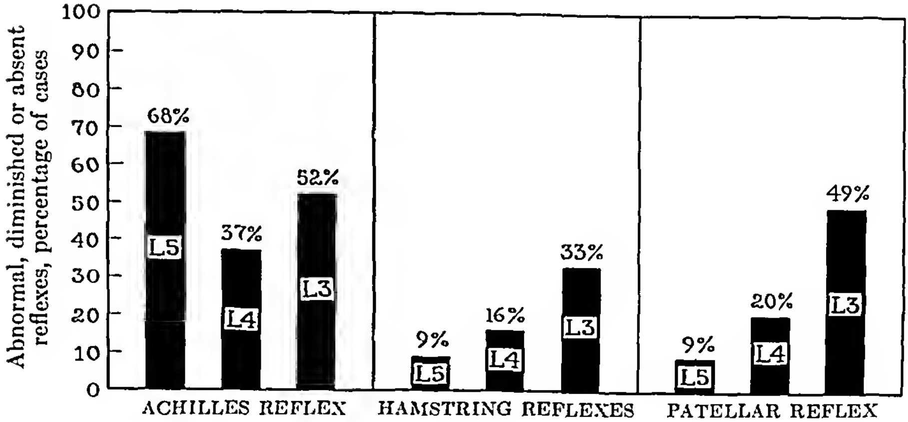

FIG. 2

Results of tests for the presence or absence of reflexes, and also for diminished reflexes, in 449 instances of protrusion of a single intervertebral disc.

careful study of the reflexes in 449 protrusions of single discs in the lumbar region (out of a complete series of 500 protrusions, both single and multiple) may be found in Figure 2.

It will be noticed that in 68 per cent. of patients with protrusions at the fifth interspace, 37 per cent. of those with protrusions at the fourth interspace, and 52 per cent. of those with protrusions at the third interspace, the Achilles reflex was either absent or diminished. Similarly confusing observations have been noted concerning the hamstring and patellar reflexes. Here it was found that 21 per cent. of the protrusions of discs at the fifth interspace, 57 per cent. of those at the fourth interspace, and 28 per cent. of those at the third interspace are accompanied by no reflex or sensory findings whatever. (These latter figures are not depicted in this study.) It is thus obvious that diminution of the Achilles reflex is more common in protrusions of the fifth interspace, and that the patellar reflex is more frequently involved in protrusions occurring at the third interspace. However, in view of the large number of patients whose condition does not fit into the scheme proposed by Spurling, its value for practical diagnosis may be questioned.

It is important to remember that involvement of one nerve root alone cannot be expected to produce sensory changes, and that consequently, only those lesions which involve two or more nerve roots will produce a loss of sensation. Spurling stated, however, that paraesthesia may be the result of involvement of one nerve root alone. In the authors' entire series of 500 cases of both single and multiple protrusions of the intervertebral disc, 50 per cent. of the patients noted paraesthesia, but only 22 per cent. had sensory loss. Careful study of the dermatomes involved in the sensory loss demonstrated that there was little if any difference between protrusions of single discs at the third, fourth, and fifth interspaces, with the fifth lumbar and first sacral, the most commonly involved dermatomes.

Jung and Brunschwig, and others reported no evidence of sensory

TABLE 1

COMPARATIVE SYMPTOMS IN 285 CASES* OF PROTRUDED INTERVERTEBRAL DISC AND 154 CASES OF INTRASPINAL TUMOR, FOR DIFFERENTIAL DIAGNOSIS

Symptoms	Protruded Intervertebral Disc (285 Cases)		Intraspinal Tumor (154 Cases)	
	Cases	Per cent.	Cases	Per cent.
Unilateral sciatic pain	215	75	58	38
Bilateral sciatic pain	42	15	36	23
Low-back pain	271	95	65	42
Nocturnal pain	61	21	73	47
Sphincteric incontinence	14	5	51	33
Lasègue's sign present	231	81	22	14
Achilles reflex diminished or absent	171	60	36	23
Hamstring reflexes diminished or absent	51	18	42	27
Muscle paresis	63	22	65	42
Muscle atrophy	5	2	39	25
Sensory loss	62	22	98	64

* These 285 cases represent those in which sensory changes were present. They are part of the complete series of 500 cases of single and multiple protrusion of the intervertebral disc in the lumbar region, mentioned in the text.

nerve supply to the intervertebral disc, although the posterior longitudinal ligament was well supplied with sensory nerves. The innervation of the annulus fibrosus and the posterior longitudinal ligament has been recently restudied carefully by Roofe, who found that each of the spinal nerves gives rise to a recurrent branch just distal to the posterior root ganglion which reenters the intervertebral foramen and supplies the ligamentous structures two vertebrae lower than the exit of the spinal nerve (Fig. 3-A). The profuse supply of sensory nerve endings in the annulus fibrosus and the posterior longitudinal ligament may account for some of the heretofore unexplained painful symptoms in cases in which the compression is limited to the lower lumbar and lumbosacral regions, and in which a tear of the annulus fibrosus has led to herniation of the intervertebral disc. It is possible that this observation also may explain the occasional puzzling observation of sensory changes in a dermatome higher than the level at which protrusion of the disc or the tumor found at operation occurred.

At the fourth intervertebral space, the fifth lumbar nerve root lies in the subarachnoid space fixed laterally against the dura, from which it emerges below the level of the fourth lumbar interspace. It passes out

beneath the pedicle of the fifth lumbar vertebra through the intervertebral foramen. All the lumbar nerve roots and their respective discs, except the first sacral nerve which separates from the dural sac above the lumbosacral disc, bear this same relationship. Thus it might be expected that posterior protrusion of the fourth intervertebral disc most commonly might involve the fifth nerve root, whereas protrusion of the fifth interspace might involve the first sacral nerve root. However, in this series of cases it has been observed not infrequently that lateral protrusion of the fifth interspace may compress the fifth nerve root, and those disc protrusions at the fourth interspace, the fourth nerve root; whereas a large posterior protrusion of a disc, particularly a midline protrusion, may compress several or even all nerve roots in the cauda equina, confusing any attempt at accurate localization of the lesion by clinical means alone.

A differential diagnosis between a tumor of the cauda equina and protruded intervertebral disc is sometimes very difficult. The marked tendency toward intermittency of symptoms (84 per cent. in the entire series of 500 cases) caused by protruded discs, as contrasted with tumors in this region of which the symptoms are more often steadily progressive, may be confusing, especially when coupled with the fact that 26 per cent. of the patients in the series had no reflex or sensory changes. In comparing the clinical changes occurring in cases of protruded intervertebral disc and intraspinal tumor, only 285 cases were analyzed in the complete series of 500 cases of single and multiple protrusion of intervertebral discs (Table I). These 285 are cases in which sensory changes occurred. The symptoms they produced are compared in Table I with symptoms produced in 154 cases of intraspinal tumor. In view of the present increased knowledge of the syndrome of protruded disc, however, it would be possible to explore the fourth and fifth lumbar interspaces directly, and avoid the use of a contrast medium, but the investigator should always keep in mind the fact that posterior protrusions of discs may occur rarely in the third, second, or first interspace, that multiple protrusion of discs may occur, and that removal of only part of the cause for the patient's symptoms cannot be expected to give symptomatic relief (Table I).

Patients who have low-back and sciatic pain may have no demonstrable lesion involving the intraspinal structures, the nerve roots, or peripheral nerves. Certain of these patients will have lesions so small and undeveloped that objective evidence of their presence or a clinical picture typical enough to permit their diagnosis on the basis of the history alone will be lacking. In addition to these, there is another group of patients who complain of sciatic pain and pain in the buttock, leg, and thigh, but in whom no organic cause for such pain is apparent. Such pain has been accepted as being referred from some adjacent or even remote pathological process.

Head wrote, ". . . where a painful stimulus is applied to a part of low sensibility in close central connection with a part of much greater sensibility the pain produced is felt in the part of higher sensibility rather

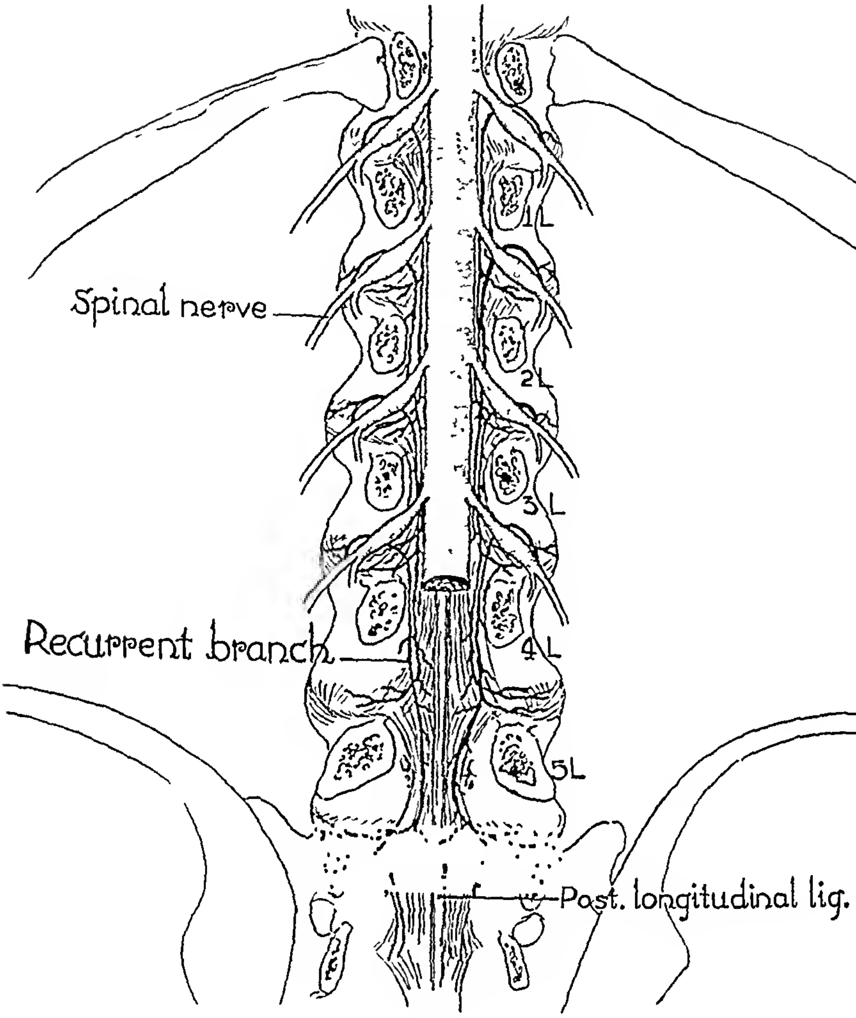

FIG. 3-A

Innervation of the intraspinal ligaments (after Spurling and Roofe).

than in the part of lower sensibility to which the stimulus was actually applied".

Referred pain is of common occurrence in the presence of intrathoracic and intra-abdominal disease,—for example, the pain felt in the left arm caused by coronary occlusion, the pain referred to the angle of the left scapula and produced by irritation of the center of the diaphragm, and the referred pain felt in the abdominal wall, referable to irritation of the periphery of the diaphragm. The explanation for such referred pain is not entirely satisfactory.

It was thought by Mackenzie that sensory manifestations of visceral disease localized in somatic regions are reflex in nature. These, he designated "viscerosensory" reflexes and explained them on the basis of hyperirritability in the corresponding segments of the spinal cord referable to exaggerated visceral stimulation. This irritation of a visceral organ sets up an exaggerated flow of nerve impulses which enter the correspond-

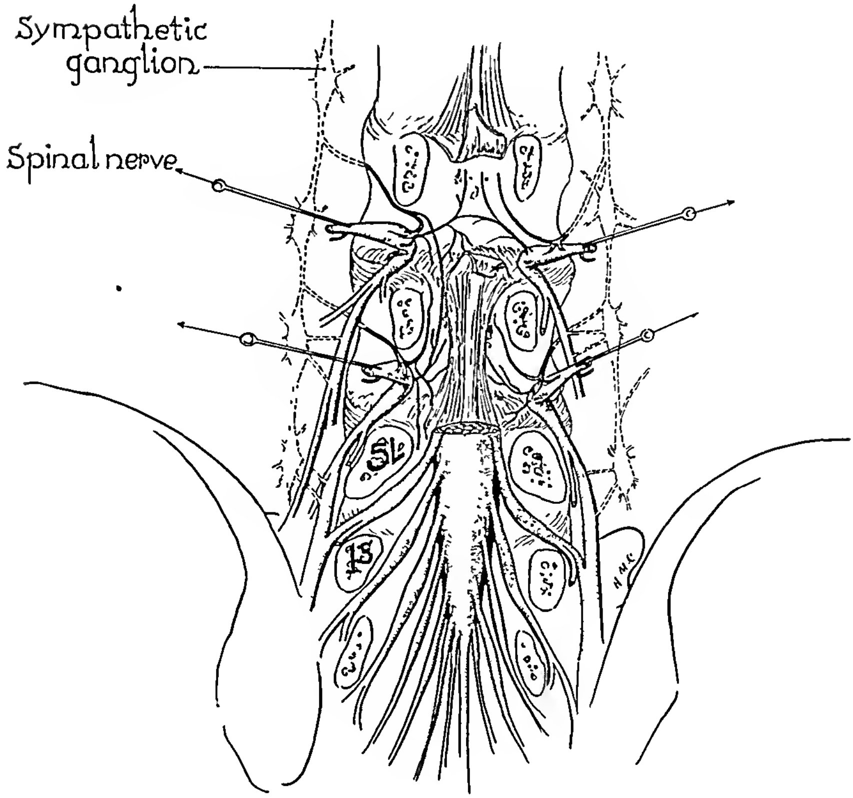

Fig. 3-B
Sympathetic innervation of the intraspinal ligaments (after Toldt).

ing segments of the spinal cord. These in turn give rise to an "irritable focus" in which the threshold of stimulation is so reduced that the normal impulses arising in the skin, muscles, and other peripheral structures produce painful sensations referred to the periphery in the somatic segments in question. Both the somatic pain or hyperalgesia and the muscular rigidity associated with visceral disease, according to Mackenzie's theory, are expressions of hyperirritability in the spinal cord, the pain or hyperalgesia being produced by exaggerated viscerosensory reflexes; the muscular rigidity, by exaggerated visceromotor reflexes.

Szemzo advanced the theory that visceral afferent fibers, in part, terminate in the posterior cell column in the spinal cord in neurons related to the spinothalamic system, and that the hyperirritability of these cells, by reason of excessive visceral stimulation, explains the phenomenon of somatic hyperalgesia in the presence of visceral disease.

The importance of impulses arising at the periphery in the phenomenon of referred pain is emphasized by the results of clinical and experimental study reported by Weiss and Davis. In twenty-five patients who experienced well-marked and definitely localized referred pains caused by visceral diseases, including angina pectoris, pleuritis (pneumonia), carcinoma of the oesophagus, gastric ulcer, cholecystitis, nephrolithiasis,

acute appendicitis, salpingitis, and pyelitis, the pain was either greatly alleviated or completely abolished by infiltration of the painful cutaneous regions with a 2-per-cent. solution of procaine hydrochloride. Referred pain induced experimentally in two normal human subjects by distention of a segment of the duodenum or the lower portion of the oesophagus by means of a rubber balloon was abolished in the same manner. These observations have been confirmed by Morley, and Rudolf and Smith. Woollard and Roberts, on the other hand, failed to abolish referred pain induced by irritation of the diaphragm, when they anaesthetized the corresponding cutaneous region.

Weiss and Davis explained their results on the basis of Mackenzie's theory of referred pain,—for example, segments of the spinal cord were rendered hyperirritable by abnormal visceral stimulation, and the normal afferent impulses from the skin entering these segments of the spinal cord gave rise to pain. The cutaneous region in which the referred pain is localized does not include the entire region supplied by afferent fibers entering the spinal segments which, according to Mackenzie's theory, are supposed to be hyperirritable. In view of this, the abolition of referred pain by means of anaesthesia of the localized cutaneous region can be explained more satisfactorily on the assumption that the pain is caused by overstimulation of the peripheral receptors by conditions produced reflexly at the periphery, the afferent impulses entering the spinal cord from the diseased or irritated viscus or the tissue adjacent to it. This view is supported by Davis and Pollock, who found that efferent stimulation of the sympathetic nerves extending into the head gave rise to pain by reason of the effect of the peripheral response to such stimulation on sensory end organs (Fig. 3-B).

The reflex arcs, through which the peripheral vasomotor and pilomotor reactions are mediated, comprise a general visceral afferent or a somatic afferent neuron, through which afferent impulses are conducted from the site of the lesion, or the irritable tissue adjacent to it, to the spinal cord. A visceral efferent neuron, situated in the intermediolateral cell column, and a sympathetic neuron, situated in the corresponding ganglion of the sympathetic trunk, conduct efferent impulses to the smooth muscle in question. In so far as cutaneous impulses are a factor in the production of referred pain, they are conducted by the pain-conducting fibers distributed to the skin and cutaneous blood vessels.

That all the nerve reactions involved in the referred somatic manifestations of visceral disease are facilitated by the hyperirritability of the centers in the spinal cord produced by the exaggerated visceral stimulation seems probable. The degree of hyperirritability produced in the spinal cord, furthermore, may be a determining factor in the intensity of both the direct visceral pain and the referred pain.

Since the joints, ligaments, muscles, and tendons of the lower part of the back are subjected to unusual strain, a study of their innervation has been made with the idea of attempting to learn in which region pain

referred from lesions of these structures might be expected to occur. Pitkin and Pheasant pointed out that dissections by Rüdinger and Smith-Petersen demonstrated the nerve supply of the sacro-iliac and sacrolumbar articulations and their accessory ligaments, and concluded that referred pain from these regions, spoken of by them as "telalgia", affects the gluteal or sacral region (or both) and that it may affect any part or all parts of the lower extremities and genito-inguinal regions except the internal crural and plantar regions.

Badgley emphasized the possibility that low-back pain with extension into the leg might be caused by a mechanism essentially produced by reference from a primary lesion, situated in the lumbar, lumbosacral, or sacro-iliac regions which was muscular, articular, or skeletal in origin.

Steindler called attention to the fact that spinal nerves are grouped into anterior and posterior primary divisions. The anterior divisions make up largely the cervical and lumbosacral plexuses, and lesions affecting these anterior divisions give rise to the well-known syndrome of radicular pain. He wrote of patients suffering from this type of referred pain as having the "posterior syndrome". It is diagnosed by the finding of tender points over the site of the lesion. Injection of these tender points with procaine hydrochloride, according to Steindler, produced important diagnostic information.

According to Steindler, Purkinje and von Luschka described the nervus sinuvertebralis which receives a white ramus from the common trunk and a gray ramus from the sympathetic chain just outside the intervertebral foramina and which turns back into the intervertebral canal, supplying the neck and head of the rib, the pedicles and the interior of the bodies of the vertebrae, the loose areolar perimeningeal tissue, and the periosteum. Von Luschka believed that they transmit the sensation of spinal irritation, paraesthesia, chilling, and sensations of heat from the spinal column. Steindler has suggested, on this basis, that reflex pain may be referable to lesions situated in the intervertebral canal rather than to direct compression of nerve roots.

Ober has emphasized the possible contracture of the fascia lata in the causation of sciatic pain, and has recommended fasciotomy for its relief. He did not mention, however, any mechanism by means of which it was produced, although it has been suggested that in this syndrome there is a referred pain of the type mentioned previously.

Macey has recently called attention to the rôle of disease of the intraspinous ligaments in the production of low-back pain, and definite disease of the intraspinous ligament has been demonstrated on biopsy. Relief of the pain which follows injection of procaine hydrochloride into the involved ligaments has been utilized as a diagnostic sign.

With these and a few other exceptions, however, pathological proof of lesions situated in the fascia, muscles, and joints usually is lacking. It is extremely probable that referred pains do occur in the lower extremity, but it is difficult to estimate their frequency in the light of present knowl-

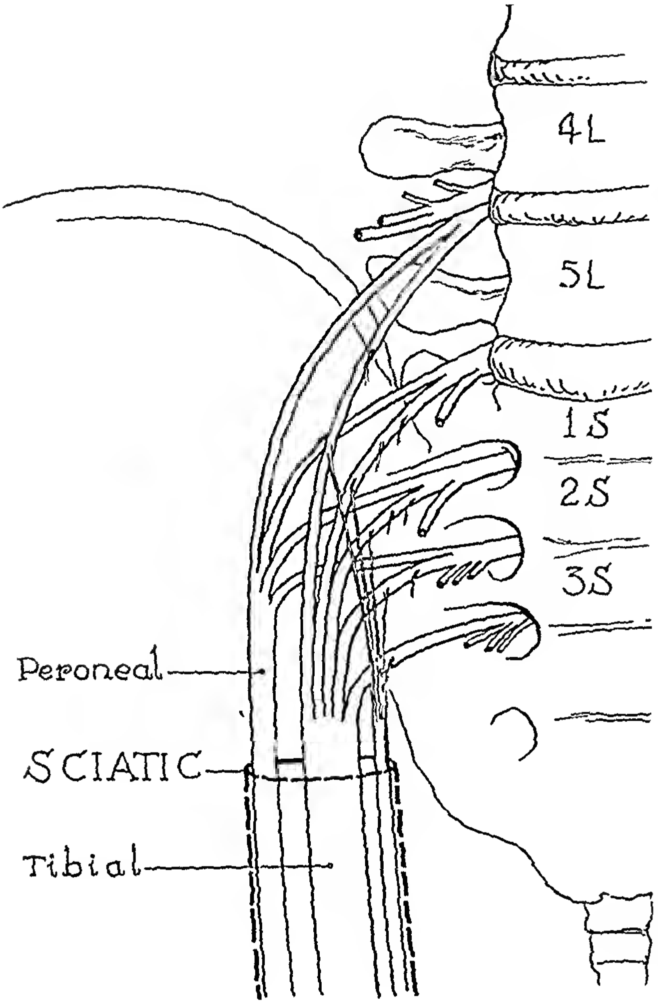

FIG. 4

Lumbosacral nerves from which the sciatic nerve is derived.

edge. An intraspinal lesion should be eliminated before the physician concludes that the patient's pain is referred from some distant focus. The structures of the lower part of the back probably are subjected to more stress and strain than those of any other region of the human spinal column. However, if pain referred from ligaments and joints of the spinal column were of extreme frequency, it might be expected that such pain would occur in the cervical and thoracic regions, and that it would be referred down the nerves of the arms and around the thorax and abdominal walls. As a matter of fact, in our experience the production of pain of this type in the arms, thorax, and abdomen, which is sufficiently localized to be confused with pain caused by radicular irritation in these regions, is extremely rare if it occurs at all.

Lesions of the nerve roots in the intervertebral foramina are relatively uncommon. Involvement of these structures by fracture of vertebral laminae, by hypertrophic osteitis of the laminae, or by marked spondylolisthesis rarely occurs. It should be emphasized, however, that the intervertebral foramina through which the nerve roots pass in leaving the spinal cord are, under most circumstances, amply large for their passage. Diagnosis of such lesions as those mentioned in this paragraph, however, is dependent on roentgenographic demonstration of the bone lesion plus neurological evidence of involvement of one or more nerve roots.

The occurrence of referred pain in patients who have pathological conditions of the intervertebral articulations has been explained by Steindler by calling attention to the nervus sinuvertebralis described by Purkinje in 1845 and by von Luschka in 1850.

After leaving the intervertebral foramina, the lumbar, sacral, and coccygeal nerves, in common with most spinal nerves, are grouped into anterior and posterior primary divisions. The lumbosacral plexus is formed by the union of the anterior primary divisions of the lumbar, sacral, and coccygeal nerves. In their relationship to sciatic pain, the lumbar and sacral plexuses will be considered separately. It should be added that sciatic pain is rarely produced by lesions of the lumbar plexus; it is, however, not infrequently produced by lesions of the sacral plexus. The nerves which supply the lower extremity have their origin in the lumbosacral plexus. The components are distributed to the lower extremities in a manner homologous and similar to the distribution of the brachial plexus to the upper extremities; the lumbar nerves are distributed similarly to the nerves formed from the anterior (medial and lateral) cords of the brachial plexus, and the sacral nerves are distributed in a manner similar to the distribution of the nerves from the posterior cord of the brachial plexus.

The anterior primary divisions of the first three lumbar nerves and the greater part of the fourth lumbar nerve form the lumbar plexus, which is situated on the posterior part of the psoas major muscle in front of the transverse processes of the lumbar vertebrae. Because of its situation, the lumbar plexus may be involved by tumors of the vertebrae or the retroperitoneal lymph nodes, psoas abscesses, or bullet wounds. Lesions of the lumbar plexus may be diagnosed by involvement of the nerve roots making up the plexus or the nerves which take origin from it, plus roentgenographic or other evidence of involvement in this region.

The sacral plexuses are formed by the lumbosacral trunk from the fourth and fifth lumbar nerves and the anterior divisions of the first, second, and third sacral nerves (Fig. 4). The sacral plexus lies, in 90 per cent. of cases, on the anterior surface of the piriformis muscle, and in 10 per cent. of cases it lies within the muscle. The sacral plexus lies behind the pelvic fascia and the branches of the hypogastric artery. It is also dorsal to coils of intestine, with the sigmoid portion of the colon in front of the left plexus and the lower part of the ileum in front of the right plexus.

When the fibers of the sacral plexus pass through the piriformis muscle and a spasm of this muscle occurs, according to Freiberg, sciatic pain may occur. The diagnosis is made by palpation of the spastic muscle by rectum and relief may be obtained by massage and physiotherapy to relax the spastic muscle, or by section of the muscle. Lesions of the sacral plexus may result from obstetrical injuries or injuries caused by forceps, bullet wounds, fractures of the head of the femur, or pelvic tumors. The diagnosis is made by recognition of involvement of the nerve roots which make up the plexus or its branches, or the nerves that take their origin from it, plus roentgenographic or other evidence of lesions in this region.

Lesions of the peripheral nerves may be caused by inflammatory affections of the nerves, trauma, pressure, or degenerative changes, and they may produce lesions which produce conditions commonly spoken of

under the heading of "neuritis". Inflammation of nerves may be primarily parenchymatous, or they may involve the sheath or the interstitial connective tissue. Thus, there is parenchymatous neuritis, perineuritis, and interstitial neuritis. However, a sharp difference cannot be established between these forms, since in all of them the parenchymatous nerve elements are involved to some degree. Interstitial neuritis or perineuritis usually is associated with true hyperaemia of the sheaths of the nerves, accompanied by transudation of serum and exudation of hematogenous leukocytes and lymphocytes. The nerve is red and swollen and the myelin sheath and the axis cylinders show some evidence of degeneration. This results in a typical degeneration of the peripheral portion of the nerve and considerable retrograde change of the central part, although the nerve sheaths are not affected.

Symptoms of neuritis vary, of course, with the severity of the affection. In perineuritis there is an extreme amount of sharp, lancinating, boring pain down the course of the nerve. Chills and fever with leukocytosis and general malaise may accompany the process. The pain is severely increased by movement of the part. The nerve trunk is swollen, frequently tender and palpable. The skin of the region supplied by the cutaneous nerve may be tender to pressure and show vasomotor changes. Sensory loss, motor weakness and paralysis, and areflexia occur.

A study of a group of patients suffering from true sciatic pain gives the impression that the term "neuralgia" should no longer be used to describe this type of pain, because most of such instances of pain probably are the result of neuritis of the sciatic nerve or its branches. Injuries to the peripheral nerves may produce the well-known phenomenon described by S. Weir Mitchell as "causalgia". This condition is most common in the hand following injury to the median nerve, but may occur in the foot or along the course of the sciatic nerve. Causalgia seldom appears when the nerve is cut completely. It occurs in the presence of incomplete injuries to the peripheral nerves when the physiological continuity of the nerve has been affected minimally. Objective sensation, although difficult to test for because of the extreme pain present, may appear to be intact. Hypalgesia, hypaesthesia, or hyperalgesia and hyperpathia may be encountered. It has been suggested that causalgia might be sympathetic in origin because of the associated vasomotor disturbances, and the emotional response of the individual to stimulation.

SUMMARY AND CONCLUSIONS

The interesting subject of sciatic pain in relationship to neuro-anatomy and physiology could be pursued at great length. In this paper we have endeavored to present the modern concepts of the outstanding causative factors in the production of such pain. That new causes for sciatic pain will be discovered in the future and that further modification of our present ideas will become necessary is inevitable. At present, however, it is undoubtedly true that more patients who have this dis-

tressing symptom of sciatic pain can be relieved of their pain than was the case at any previous period of medical history.

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CONSERVATIVE TREATMENT OF SCIATIC PAIN IN LOW-BACK DISABILITY

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This paper is a description of the conservative treatment and a report of the results in 1000 patients seen for sciatic pain and low-back disability during the past ten years. By conservative treatment is meant the use of rest in special positions, support, medications, and physiotherapy. It does not include manipulative and operative procedures. In this group of 1000 patients there were 390 males and 610 females. There were fifty-two under twenty and eighty-two over sixty years of age. It is difficult to divide low-back pain into acute and chronic. In 519 the low-back pain had been present for two weeks or less, and in 481 it was of longer duration. The affections of 576 of these 1000 patients were diagnosed primarily as muscular or ligamentous strains in the region of the low-lumbar spine and sacrum. In 325 others a ligamentous strain was diagnosed in conjunction with disease or deformity of the vertebrae.

Sciatic pain, like other symptoms in low-back disability, was not a constant finding. At the time of examination, radiation of pain through branches of the sciatic nerve was present in 449 of these patients as follows: in 410 to the cutaneous distribution of the posterior femoral cutaneous and common peroneal nerves; in twenty-eight to the cutaneous distribution of the sural and superficial peroneal nerves; in seven to the distribution of the tibial nerve; and in four to the posterior femoral cutaneous distribution of both legs. In forty-three patients the radiation was along the middle and inferior gluteal nerves; in nine, the pain was complained of in the cutaneous distribution of the anterior femoral cutaneous nerve; and in four, the radiation was along the cutaneous distribution of the lateral femoral cutaneous nerve (Table II). In 409 of these patients the cutaneous radiation of pain could be interpreted only as a reflex phenomenon, a referring of pain from injured structures to the cutaneous distribution of the same nerve roots. Only approximate localization of the lesion from the referred pain was possible. In ninety patients there was extensive arthritic proliferation about the neural foramina with possible impingement upon the nerve roots. In six patients lesions within the spinal canal, which caused pressure upon the nerve roots, were demonstrated.

In most instances of low-back pain, the lesion causing the pain is presumed to be a ligamentous tear or a separation of fibers at the musculotendinous junction[5] (Fig. 1). As evidence for this assumption we have local tenderness over ligamentous structures. In a few instances there are superficial ecchymoses. Novocain injections into the most tender areas often produce temporary relief. Disappearance of the pain and disability is frequently observed following immobilization and support with attempted relaxation of the injured part of the back. Roentgenograms for

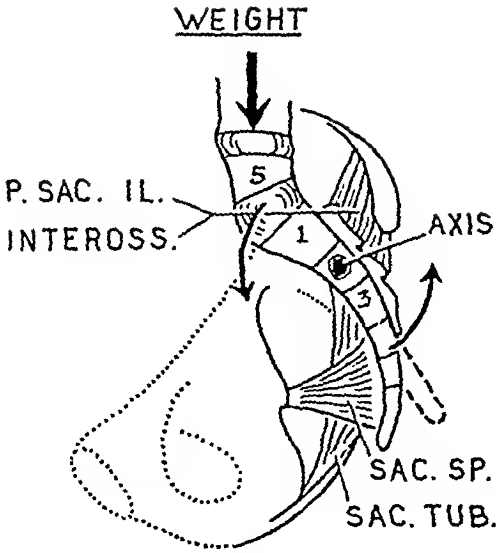

FIG. 1

Shows the common points of strain at the lumbosacral region and sacrum. *P. Sac. Il.:* posterior sacro-iliac ligament; *Sac. Sp.:* s[illegible] *Sac. Tub.* [illegible] (From A [illegible] scriptive and Deductive, by J. C. B. Grant, William Wood & Company, 1937. *Used by permission of Dr. J. C. B. Grant and The Williams & Wilkins Company.*)

soft-tissue detail are invariably negative. There are no early pathological studies recorded and operative procedures upon these patients are always performed too late to show any soft-part lesion.

A number of methods have been described recently for arriving at a more precise understanding of the pathological lesion responsible for the low-back pain. Steindler's studies aided in tracing the elusive referred pain from injured ligaments or the articular capsule. Operative attempts at muscular and ligamentous release have given suggestive evidence of the location of the lesion[7]. The work of Pitkin and Pheasant has pointed to the ligaments about the sacro-iliac and lumbosacral joints as the cause of the pain. In recent studies in a small number of patients the source of the pain has been found in the spinal canal[1] or in the neural foramina. Discussion of articular displacements or subluxations will not be undertaken, since the treatment of these does not come primarily under conservative therapy. Even the minor ones, described recently by Mennell, or those believed by the osteopath to be present in low-back pain, cannot be demonstrated clinically or roentgenographically.

It is recognized by anthropologists and by students of anatomy that the region of the spine at its attachment to the sacrum is frequently insecure and potentially weak[10]. Congenital anomalies are common at this area, and in addition there are many diseases, such as arthritis, which limit motion and lead to sprains and other injuries. Roentgenographic examination of these patients showed 375 abnormalities of the lumbar spine and sacrum in 323 of the 1000 patients. The anatomical and pathological changes are shown in Table I.

All of the congenital anomalies and many of the pathological changes, which interfered with the normal stability and balance of the spine, had been present for a long time before low-back pain appeared. In the presence of congenital anomalies, and faulty body mechanics which hasten the appearance of symptoms by causing malalignment of the spine and inefficient functioning of the supporting structures[3], a slight trauma, such as a sudden unguarded movement, may produce a severe sprain of the low back. The instability induced in the low back by the faulty body

TABLE I

ANATOMICAL AND PATHOLOGICAL CHANGES IN THE VERTEBRAE

Hypertrophic arthritis	96
Atrophic arthritis	70
Lumbosacral transverse joint	64
Spina bifida	50
Defective articular facets	45
Six lumbar vertebrae	14
Structural scoliosis	7
Fracture of lumbar spine	6
Metastatic malignancy	3
Epiphysitis of the spine	3
Spondylolisthesis	3
Tuberculosis of the hip	2
Tuberculosis of the spine	2
Paget's disease	2
Narrowing of the lumbosacral disc	2
Fused spine	2
Fracture of the pelvis	2
Short leg	1
Thirteen dorsal vertebrae	1
	375

mechanics is shown in roentgenograms by the tendency of the sacrum to assume a more nearly horizontal position, by the thrust of weight coming upon the articular facets at the limit of extension, by the increase in the lordosis with overriding spinous processes, and by the rotation and marked downward displacement of the lower ribs (Fig. 2).

What can be regarded as adequate treatment of the usual cause of low-back disability,—a muscular or ligamentous tear in the supporting structures of the lumbar spine and pelvis? It would be reasonable to believe that the treatment would be similar to that applied to muscular and ligamentous tears elsewhere in the body,—that is, rest with the injured structures in a position of relaxation until healing is at least partially completed. The author does not know how long it requires for a ligamentous tear to heal completely. From studies by Dehne [2] upon ligaments of dogs of a similar size, it should take at least two months.

What is the position of relaxation? Here we have considerable clinical and anatomical data. It is possible to secure relaxation of most of the posterior ligamentous structures about the sacrum and lumbar spine by supine recumbency with the lumbar spine flat, and with slight flexion (20 to 30 degrees) of the hips. This has been demonstrated in the cadaver. From observations upon the cadaver or the partially dissected lumbar spine and pelvis, the author can find no mechanical basis for traction upon the legs in extension for relief of the usual types of low-back pain. It does not aid ligamentous relaxation in the low back, or relieve muscular spasm in the lumbar region, but it does lead to immobilization of the spine in faulty positions.

The best method of securing immobilization and ligamentous

FIG. 2
Lateral roentgenogram of lumbar spine and pelvis, showing marked forward inclination of the pelvis with the sacrum approaching the horizontal. The articular facets are used at the extreme of extension. There are impinging spinous processes and depression of the lower ribs.

relaxation for the low back is to keep the patient constantly on a firm bed with the entire body horizontal except for slight flexion at the hip joint. This can be secured in the supine position by placing a pillow under the knees, or in the prone position, under the abdomen (Fig. 3). With very severe ligamentous injury it may be necessary to apply a plaster back shell or a plaster spica to hold the patient more continuously in this position temporarily. Only in the mildest of low-back injuries is the patient permitted to be ambulatory. The common tendency is to underestimate the severity of the injury.

In most instances while the patient is in bed, physiotherapy, consisting of heat daily, should be given to the posterior surface of the spine and pelvis to improve the local circulation, to relax muscle spasm, to relieve pain, and to hasten the absorption of inflammatory exudate[4]. This can be applied in a position of ligamentous relaxation with the patient prone by placing a pillow under the abdomen. In most instances it will be possible to permit the patient to sit up for meals and to use a cabinet chair for bowel evacuation without disturbing the healing process. As soon as muscle spasm and pain begin to subside and the patient can move in the bed without much discomfort, exercises can be given to the patient to teach him muscular coordination so that he may improve the balance and carriage of the entire body to prevent further strain. The period that the patient must be kept recumbent varies greatly. It is usually longer in chronic conditions than in acute ones. The average period of complete recumbency in this group was ten days. Complete recumbency should be continued until pain and local tenderness have almost entirely subsided.

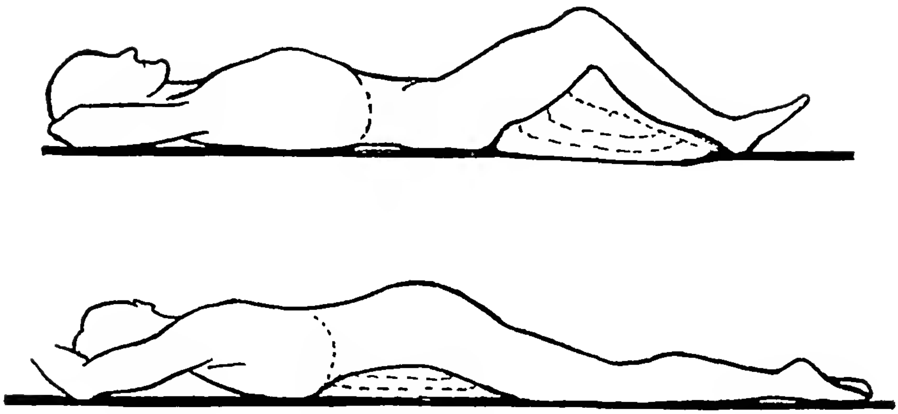

Fig. 3

The positions assumed by the patient in bed to relax the muscles and ligamentous structures of the low back and the sacrum.

This does not mean the end of treatment. Usually a prolonged period of convalescence is required until the individual is again able to assume his usual activities. Physiotherapy in the form of heat, exercises, and recumbent rest in positions which do not sprain the low back for part of the day are continued for a longer period. If the patient is not pushed beyond his physical capacity and if the ligaments are prevented from being overstretched during healing, a gradual improvement in symptoms, in muscular tonus, and in good carriage should be observed.

Because it requires a prolonged period to heal a ligamentous tear and because recurrence of the lesion may occur by an unguarded movement during convalescence, a spinal support is usually required. There are many kinds which can be effective if they are applied properly. The following are the criteria of a good spinal support:

1. It should be long enough to extend several vertebrae beyond those attached to the sprained ligaments.
2. It should be firmly attached to the pelvis.
3. It should be fitted to hold the joints of the lumbar spine in a position midway between flexion and extension, the optimum position for function (Fig. 4).

Treatment should attempt to relieve the immediate disability and also should do whatever is possible to avoid a recurrence. This will include improvement of general health, reduction of obesity, better habits of work and leisure, the easing of social maladjustments, and many others. In regard to the spine itself, prolonged guidance as the patient is beginning to resume his work is important. The spinal support should be discarded gradually as the patient loses his pain and limitation of motion, and learns how to use the body habitually in a position which is not at the extreme of extension, but midway between full extension and flexion. This is the position seen in good body mechanics.

With such treatment continued until subjective symptoms and objective signs subside what can be expected? In this group it required an

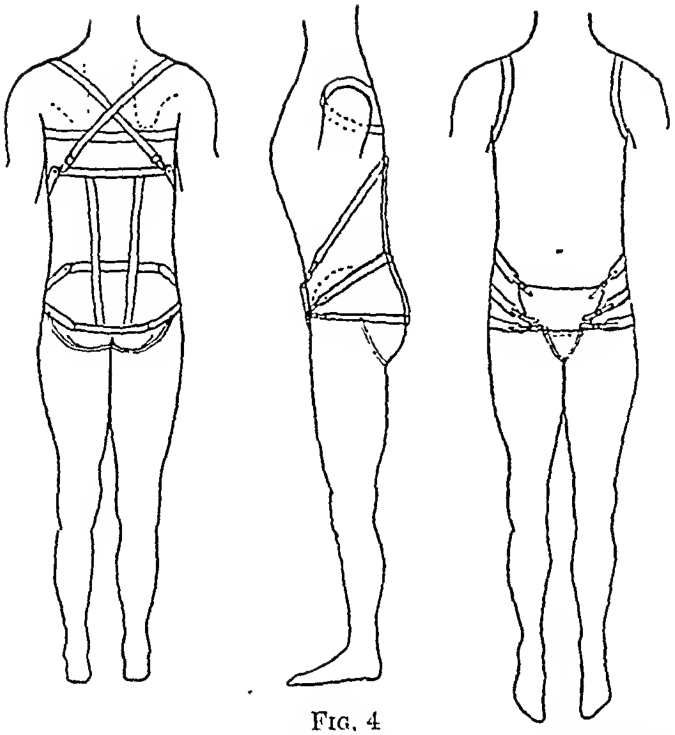

FIG. 4

Spinal support used during convalescence in the treatment of low-back pain. The shoulder straps are not used if there are no symptoms in the upper dorsal or cervical regions. Note the firm grasp of the pelvis, the fitting of the support to hold the spinal joints in a position not at the extremes of their motion, and the avoidance of compression upon the supporting muscles of the back and abdomen. (From Body Mechanics in the Study and Treatment of Disease, by Joel E. Goldthwait, Lloyd T. Brown, Loring T. Swaim, and John G. Kuhns. Ed. 2 Philadelphia, J. B. Lippincott Co., 1937. *Courtesy of J. B. Lippincott Company.*)

average of forty-eight days before the spinal symptoms and signs subsided and the patients returned to their work, with extremes of one week and ten months. A large number of patients who return and continue at work are never wholly free of symptoms, although physical signs do not suggest any serious lesion in the spine. The reasons for their continued symptoms are varied. It may be a chronic arthritis, or a congenital anomaly making a potentially weak back, or working long hours with the back bent, or the inability of the patient to learn to use the body in a more correct habitual position. A permanent muscle weakness may lead to slight recurrent strain when the patient works too strenuously. Certain of these recurrences can be relieved by more radical procedures, but often these slight symptoms will recur even after surgical correction of the supposed cause.

The effect of conservative treatment in the relief of both local and referred pain is shown in Table II. Relief of pain was observed in 771 of the entire group. In those with sciatic radiation of pain, the pain

TABLE II

RESULTS OF CONSERVATIVE TREATMENT IN THE RELIEF OF PAIN

	No.	Relieved	Unrelieved	Unknown
Local pain only	495	374	35	86
Sciatic radiation	449	356	31	62
Gluteal radiation	43	31	5	7
Anterior thigh radiation	9	6	1	2
Lateral thigh radiation	4	4	0	0
Totals	1000	771	72	157

disappeared in 356 of 449 patients, or about 79 per cent. There was no appreciable difference in the relief of pain in the various cutaneous distributions. The alleviation of pain is not the only factor which determines whether the individual is disabled from lesions in the low back. If the pain is not severe the patient will often continue at his usual activities.

If this study is to be of value it should suggest which types of low-back pain will probably be relieved under conservative treatment (Table III) and which will probably not be helped by conservative treatment alone. The types of low-back disability can be placed in four large categories:

1. *Acute Traumatic and Chronic Postural Strains of the Low Back.* All of these patients can be expected to recover under conservative treatment. The length of time that treatment must be continued will depend upon the severity of the trauma, the chronicity of lesion, and the cooperation of the patient.

In a small number of patients a change from full extension of the spinal joints to one of relative flexion cannot be obtained by conservative measures alone. This can be demonstrated by lateral roentgenograms (Figs. 5-A and 5-B), with the thighs extended and flexed upon the abdomen. If, after two weeks of adequate, conservative treatment, no motion can be demonstrated in the spinal joints of the low back, other measures, most commonly manipulation of the low back, are indicated. After normal mobility has again been obtained in the low spinal joints, conservative measures should be resumed until the patient has recovered.

2. *Structural Changes in the Vertebrae or Their Contiguous Structures.* If the normal osseous contour is again established and adequate fixation is given, conservative treatment is needed to recover normal function. In other diseases where there is much deformity or disturbance of stability, an attempt should be made to correct this; then conservative treatment may be given. Where structural restoration cannot be expected, as in metastatic malignancies, conservative therapy may prolong function and is of great help in palliative treatment.

3. *Low-Back Pain from Pressure or Irritation within or about the Spinal Canal.* In this group conservative treatment may be of little avail. Here, if there is a definite lesion—namely, a ruptured nucleus pulposus or a spinal cord tumor—its removal is indicated.

TABLE III

RESULTS OF CONSERVATIVE TREATMENT IN THE RELIEF OF DISABILITY

	No.	Improved	Unimproved	Unknown
Acute traumatic and chronic postural strains	904	744	47	112
Structural changes in the vertebrae	90	47	8	35
Pain from pressure or irritation within the spinal canal	6	0	6	0
Pain referred from other parts of the body	0	0	0	0
Totals	1000	791	61	147

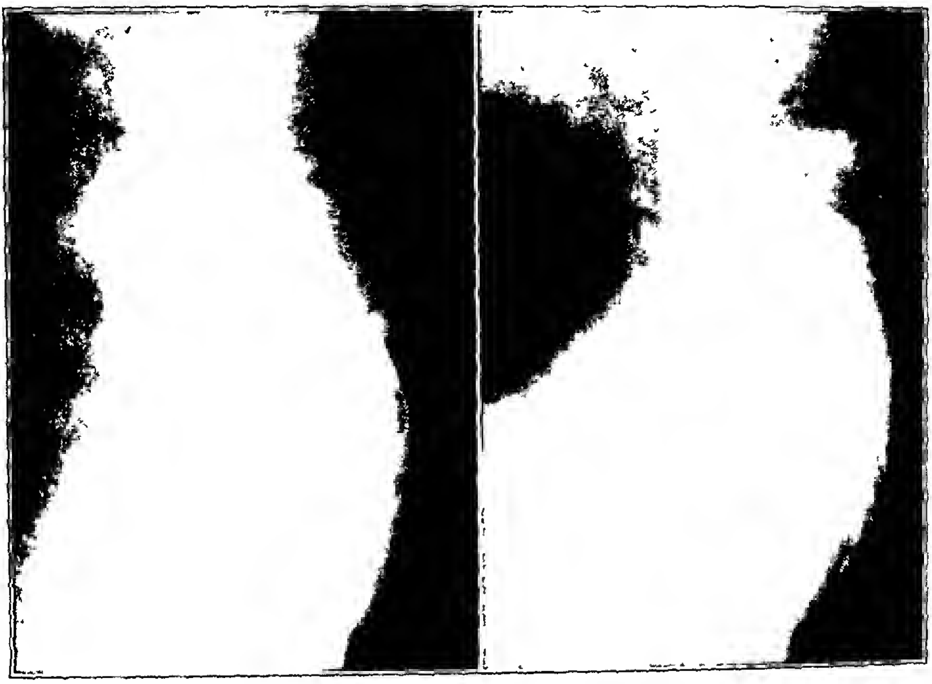

FIG. 5-A FIG. 5-B

Lateral roentgenograms of the lumbar spine and pelvis.

Fig. 5-A shows the position of the sacrum and articular facets with the thighs extended.

Fig. 5-B shows good mobility in the lower spinal joints when the thighs are flexed upon the abdomen.

4. *Pain Referred to the Back from other Parts of the Body, Usually the Abdominal and Pelvic Viscera.* There were no patients in this 1000 cases with low-back pain of this type. Here the lesion, which causes pain referred to the low back, should be treated.

SUMMARY

Low-back disability with sciatic radiation may arise from an infinite number of causes. The most frequent cause is injury to the ligaments, muscles, and fascia supporting or investing the low back or pelvis. The cutaneous radiation is most commonly a reflex phenomenon, a referring of pain from deep structures to the cutaneous distribution of the same nerve root. The lumbosacral region of the spine is the weakest portion of the vertebral column. Contributing factors to sprains at this area are anomalies and diseases of the vertebrae and faulty habits of use of the body. Faulty body mechanics leads to impaired functioning of the muscle supports, defects in balance against gravity, and the tendency of the low spinal joints to be used at the limit of their extension.

Adequate conservative treatment should include rest of the entire spine in a good mechanical position on a firm surface, heat applied to the injured portion of the spine, and, when movements can be performed with relative comfort, exercises to teach the patient how to use the body habitually in good body mechanics. Later when the patient is first ambula-

tory, a support should be fitted with the patient's body in the best corrected posture possible, so that strain will not come upon the healing structures.

Pain referred along the sciatic nerve is relieved by such treatment in approximately 79 per cent. of all patients who present this symptom. When we group patients according to the cause of the disability we find that low-back disability caused by ligamentous and muscular strains responds most frequently to conservative treatment.

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POSTERIOR PROTRUSION OF THE LUMBAR INTERVERTEBRAL DISCS *

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For many years orthopaedic surgeons have been studying the problem of low-back and sciatic pain, and have recognized that in the majority of cases the cause of the patient's disability is mechanical. An exact classification of the various types of mechanical derangement is impossible unless the pathological anatomy can be demonstrated either on the operating table or at autopsy. Within the past decade it has been discovered that one of the common mechanical derangements causing sciatica is posterior protrusion of the lumbar intervertebral discs. The increase in the number of patients operated upon for this condition is shown in Table I.

PATHOLOGY

The limited time at the authors' disposal precludes a complete discussion of the anatomy and pathology of intervertebral-disc lesions. The recent reviews by Saunders and Inman are both comprehensive and accurate. The normal intervertebral disc cushions the central nervous system from trauma and serves to transmit the body weight from one vertebra to another and to permit mobility of the spine. Each disc possesses a certain turgor or internal hydrostatic pressure, which, as measured by Petter, amounts to thirty pounds for the lumbar discs. This internal pressure is, of course, markedly increased during certain of our normal activities; for instance, if a man is lifting a 100-pound weight, the lumbar intervertebral discs are subjected to the weight of the body above them, to the 100-pound weight, and, in addition, to the compressive force exerted by the trunk muscles contracting between the pelvis and the thoracic cage. Extrusion of the nucleus pulposus may occur in any direction following weakening of its surrounding tissues by developmental defect, disease, degenerative change, or trauma. If the cartilaginous end plate is weakened, protrusion may occur into a vertebral body. Although such *Knorpelknötchen* may cause local backache, they apparently never cause radiating pain.

* The statistical data of this paper are compiled from the records of 139 consecutive proved cases of posterior intervertebral-disc protrusions in the lumbar region, operated upon at the Massachusetts General Hospital for a chief complaint of "sciatic" pain. A few cases reported in previous papers have been omitted, either because they were operated upon at other hospitals and end-result data are not available, or because on restudy they did not seem to fit the syndrome. This accounts for various minor statistical discrepancies between this and others of our papers.

TABLE I

Number of Operations Performed for Posterior Protrusion of Lumbar Intervertebral Discs at the Massachusetts General Hospital up to January 1940

Year	No.	Year	No.
1925	1*	1934	5
1927	1*	1935	8
1930	2*	1936	23
1931	1*	1937	19
1932	5	1938	27
1933	1	1939	48†
		Total	141†

* These were recognized as ruptured discs only after restudy of the histological material in 1932.

† Includes two recurrences.

Posterior protrusions in the low lumbar region sufficiently large to press on one or more roots of the lumbosacral plexus cause a very definite train of symptoms and signs, which have been described in detail in previous communications. In a series of 155 cases of proved intervertebral-disc protrusion into the spinal canal, verified by operation at the Massachusetts General Hospital, 139, or 90 per cent., occurred in the lumbar region, the fourth and fifth lumbar discs being the favored locations. The lesion is laterally placed, usually directly beneath the articular facet, and, when of sufficient size compresses the nerve root between the ruptured disc and the facet just before its exit through the intervertebral foramen. A lesion at the fourth lumbar disc invariably compresses the fifth lumbar root, while a lesion at the fifth lumbar disc invariably compresses the first sacral root, providing the protrusions are of sufficient size to cause any nerve-root pressure. This is due to the fixation of the root in its dural sheath at its point of exit through the intervertebral foramen. The other roots lying free in the cauda equina are easily displaced to one side and so avoid pressure in most instances. Occasionally the lesion is so large that it completely occludes the dural sac. The lesion, as seen at operation, usually presents itself as a small, elastic, pea-sized nodule lying beneath the posterior longitudinal ligament and on incision of the ligament can be removed as a rolled-up, completely detached bit of intervertebral-disc tissue. Occasionally, the fragment is still attached to the disc but produces a localized protrusion. Rarely there is a generalized backward bulging or prominence of the whole posterior disc margin with a resultant transverse indentation of the ventral surface of the dural sac. The nerve root impinged upon is, of course, definitely flattened at the point of pressure, and there is oedema and injection of the involved nerve root proximal to the level of the lesion. There is associated local thickening of the ligamentum flavum in a fairly high percentage of cases of proved ruptured discs. Abnormal mobility of the involved interspace may be demon-

strated in some of the cases, and in a few instances, on opening the dura, chronic adhesive arachnoiditis has been demonstrated.

ETIOLOGY

There seem to be two possible explanations for the presence of these protrusions. They may be due to sudden rupture of the annulus fibrosus, the result of raising the internal disc pressure above the breaking point of the annulus fibrosus, with protrusion of the nucleus pulposus. The history of certain of the authors' patients would lead to the belief that this can and does occur clinically. It is analogous to the blow-out of an automobile tire.

A second explanation is that a fissure occurs in the annulus fibrosus as the result of the wear and tear of ordinary use or of degenerative change, and through this fissure there is a slow, gradual extrusion of disc tissue with final resultant symptoms of sciatica when the extruded mass becomes large enough to press upon a nerve root. Clinical cases of this type may have recurring episodes of low backache over many years before the extruded mass becomes large enough to precipitate an attack of sciatica.

Finally, there are small posterior protrusions which Schmorl found in about 15 per cent. of autopsies, and which he considered to be congenital in origin and of no clinical significance. There can be no doubt of the existence of such congenital lesions, but they seem to bear no direct relationship to the ruptures described here, as they occur in a higher percentage of females than of males and show no predilection for the low lumbar spine.

The symptoms and signs of a ruptured lumbar intervertebral disc are most variable, but the general pattern is so uniform that the presumptive diagnosis can often be made without contrast myelography. A common type of case history follows:

A vigorous man in his thirties was perfectly well until, while lifting a heavy weight, he felt something "snap" in his low back and had immediate pain in the lumbosacral region. Sometime thereafter he developed "sciatica" in one leg, which he describes as a deep-seated pain beginning in the buttock, radiating down the posterior thigh, the posterolateral aspect of the calf, and occasionally going into the lateral border of the foot or the great toe. Coughing and sneezing, bending forward to tie the shoes, and lying face down in bed cause a marked increase in the radiating pain. If an uncomfortable position is maintained for a time, the leg tingles, and the foot may "go to sleep". There have been two or three separate periods of disability, the first ones relieved by rest in bed; the last one, however, has not yielded to conservative measures including back-strapping, heat, bed-rest, plaster casts, corset, and osteopathic manipulation. On examination the patient is found to stand with his trunk thrust forward and to one side, with most of his weight borne on the non-painful leg—"sciatic scoliosis". The normal lumbar lordosis has been lost, and in its place is a fixed reversal of the lumbar curve, with prominence of the spinous processes of the third, fourth, and fifth lumbar vertebrae. All motions of the lumbar spine are considerably restricted by involuntary muscle spasm. The patient's finger tips cannot possibly be made to touch the floor if the knees are kept straight. The fixed list of the spine and pelvic tilt are uninfluenced by a lift under either foot. Forced hyperextension causes severe radiating pain. In the sitting position, the trunk can be flexed at the hips with ease, so that the chest approaches the knees, but

observation reveals that the lumbar spine remains in its fixed position and goes forward *en bloc*. The list of the lumbar spine may not be so noticeable, but side bending remains restricted.

The patient gets into bed or on to the examining table with extreme care. Turning over on the table is an ordeal, and he is unable to lie face down until a fat pillow is placed beneath the abdomen. In that position on palpation there is found definite local tenderness in the mid-line between the fourth and fifth lumbar spinous processes or at the lumbosacral junction. Percussion over these spinous processes may cause radiating sciatica, as may jugular compression (Naffziger's sign). There may be a little tenderness at the sacrosciatic notch on the affected side and over the course of the sciatic nerve. Inspection reveals some atrophy of the buttock, thigh, and calf on the painful side. The ankle jerk is usually diminished or absent on the painful side, and normal on the other. Peripheral, sensory, or motor changes are found in less than half the cases. Straight-leg raising may be somewhat limited on the non-painful side, and is markedly limited on the painful side. Lasègue's sign may be positive.

A history and physical examination similar to this suggest strongly that the diagnosis is posterior protrusion of one of the lower lumbar intervertebral discs.

The clinical differentiation of lesions at the lumbosacral junction from those one or two discs higher is extremely difficult, and no really reliable method is yet available. The distribution of the radiating pain does not correspond to the sensory dermatomes. Spurling and Bradford suggest that if subjective or objective sensory changes are present (that is, paraesthesia, hypaesthesia, or anaesthesia) in the anterolateral calf and great toe, the lesion is between the fourth and fifth lumbar vertebrae, while involvement of the lateral calf and lateral border of the foot indicates a lumbosacral lesion. Although this differential diagnosis would be most useful, the authors in their series of cases have not been able to verify its reliability. Their statement that the ankle jerk is absent or diminished if the lumbosacral disc is involved, and present if the disc between the fourth and fifth lumbar vertebrae is involved is also not a reliable diagnostic differential point.

The usual anteroposterior and lateral roentgenograms are of some diagnostic aid. They may be entirely normal, as the displaced disc tissue casts no roentgenographic shadow, and may be too small in volume to cause apparent narrowing of the intervertebral spaces. However, a definitely narrowed space between the fourth and fifth lumbar vertebrae is of some diagnostic importance. A narrow lumbosacral interspace occurs about as frequently as other congenital abnormalities, such as sacralized transverse processes and spina bifida, and should be considered as an incidental finding unless there are other changes present, such as osteosclerosis or spur formation, to suggest that the narrow disc is not congenital but acquired. If the fifth lumbar vertebra is sacralized, the rupture is almost invariably above it. The scoliosis and kyphosis noted clinically are also seen on the roentgenogram.

The next step in diagnosis is the lumbar puncture, which should be done as low as possible, preferably at the lumbosacral interspace. The first two cubic centimeters of fluid removed should be sent as a separate

specimen for determination of the total protein. After careful manometric tests to rule out dynamic block, further fluid is withdrawn for cytological study, and for Wassermann and colloidal-gold tests. A total protein higher than 35 or 40 milligrams per 100 cubic centimeters is confirmatory evidence that the pathological process is intraspinal. The authors have a few proved cases in their series which have had normal total protein, but the average figure has been above 60 milligrams per 100 cubic centimeters. As the lesion is usually at one of the two lowest intervertebral discs, the lumbar-puncture needle is seldom placed caudal to it, and it is rare to find any dynamic block.

The differential diagnosis between protruded intervertebral discs and other causes of sciatica cannot be discussed here. It must not be forgotten that sciatic pain of any origin is accompanied by limitation of motion of the lumbar spine, limitation of straight-leg raising, and diminution or absence of the ankle jerk. There is no single symptom or sign from which the diagnosis can be made. There is no easy road to correct diagnosis which can supplant the time-honored method of careful history-taking, complete physical examination, and the evaluation of that information in the light of appropriate laboratory tests. Malignant tumors, primary and metastatic, infectious lesions of the low back, including the sacro-iliac joints, arthritis, including the Strümpell-Marie as well as the hypertrophic types, must all be considered among the organic causes. On the other side of the ledger are all the strains, sprains, and subluxations of the lumbosacral and sacro-iliac joints, and of the ligaments and muscles controlling them. Diagnostic problems and errors must arise to plague all of us, even when the combined skill of the internist, neurologist, roentgenologist, and orthopaedist are directed toward the solution of the problem.

Preoperative diagnosis and localization of the lesion by means of contrast myelography is the next procedure to be considered. Iodized oil (lipiodol) is considered by competent roentgenologists[4, 6] to be the most satisfactory medium. Its use led to accurate preoperative localization in most of our cases, and without it the evolution of our knowledge of this clinical entity would have been much retarded. However, in five cases the lipiodol roentgenographic examination was positive, but the exploratory operation proved to be negative. In two of the nine cases in which the lipiodol roentgenographic examination was negative, ruptured discs were found at the time of the exploratory operation.

There has been a good deal of acrimonious discussion concerning the use of a contrast medium such as lipiodol for the localization of intraspinal lesions. Spurling suggests that clinical diagnosis and localization may be so accurate that the use of a contrast medium is unnecessary. Chamberlain and his coworkers state that lipiodol is dangerous and that air or oxygen myelography yield exact diagnostic information.

In a series of cases in which the authors have used both air and lipiodol myelography, they have found that the former is diagnostically accurate in not over 50 to 60 per cent. of the cases, while lipiodol is

accurate in over 90 per cent. The authors sometimes make air or oxygen myelograms at the time of the lumbar puncture, and if unequivocal, positive information is obtained, they proceed with the operation, but if the myelograms are negative or doubtful, lipiodol is injected a few days later. The lipiodol examination gives so much more accurate, dependable information that many workers have stopped using air or oxygen myelography. Lipiodol in the authors' hands and in the experience of other competent observers has proved to be the best of contrast media so far available. The risk of complications from its use is not great, and if it is reserved for those cases in which conservative treatment has failed, it becomes a preoperative localizing diagnostic test reserved for patients in whom clinical and other laboratory examinations make the diagnosis of a lesion in the low-lumbar spine almost certain. Under these circumstances, a lesion will be demonstrated and accurately localized in a very high percentage of cases. In two cases of this series no lesion was demonstrated on lipiodol examination, but exploratory laminectomy revealed a ruptured lumbosacral disc pressing on the first sacral nerve root, but not encroaching on the thecal sac. The lipiodol is always removed as completely as possible at the time of the operation. The technique of lipiodol and pneumomyelography has been described elsewhere. Thorotrast seems to the authors to entail too much risk to warrant its use. They have hesitated to recommend exploratory laminectomy unless the lesion has been diagnosed and localized by myelography. Occasionally such a procedure is justified and may become more so as greater skill in clinical diagnosis and localization is acquired. The discovery of an absorbable, innocuous, contrast medium of the density of lipiodol is awaited.*

METHODS OF TREATMENT

The authors' cases are selected for operation on the following basis: Operation is reserved for those who have had adequate conservative treatment under competent direction without satisfactory relief of symptoms, and for those who, although they may have had no conservative treatment, have definite evidence of serious nerve-root pressure (areas of anaesthesia, motor weakness, or paralysis, loss of sphincter control, etc.). The operative technique has been described by Mixter, Love, Fincher, and others. Suffice it to say that a partial laminectomy, in which adjacent portions of two laminae are removed but the continuity of no whole lamina is sacrificed, is usually sufficient for exposure and removal of the lesion and removal of the lipiodol if it has been left in the lumbar sac. If marked abnormal mobility is demonstrated at the site of the lesion, or if an articular facet has been sacrificed, the involved area (the fourth lumbar to the first sacral vertebrae) is fused. This can be easily performed on the side opposite the lesion. A modified Hibbs method reinforcing the fusion

* Since this paper was read, a satisfactory method for the removal of lipiodol has been worked out[7]. This makes it unnecessary to operate on those cases that have had negative lipiodol examination and obviates the danger of late arachnoiditis due to irritation from retained lipiodol.

with an osteoperiosteal graft and additional bone chips from the tibia is used. No attempt is made to bridge the laminectomy defect. There is a definite place for fusion in selected cases, and about one-third of this series of cases are fused. Whether fusion is performed or not, strenuous activity, heavy work, etc., are not permitted for six months after operation. It is unnecessary to emphasize that muscular rehabilitation by means of carefully graded exercises should be an integral part of the post-operative care of every patient. Details of after-care vary with the physician in charge.

CONSERVATIVE TREATMENT

There is a good deal of clinical evidence leading to the conclusion that the lesion under discussion is by no means rare and that many patients with low-back pain and sciatica, whose symptoms are mild or who recover under conservative treatment, have a protruded disc as the cause of their symptoms. The only way of obtaining exact evidence on that would be to inject lipiodol into the spinal canal of a large consecutive series of cases of low-back strain and to follow them carefully without operation. Ten patients in our series with a typical or suggestive defect, as shown by examination with lipiodol, and a large number of others who clinically seemed to have protruded discs have been treated conservatively. The use of a plaster jacket applied with the lumbar spine in slight flexion seems to be the most efficacious method of immobilization. The patient whose symptoms are not relieved within a few weeks by bed-rest or by the application of such a jacket usually requires surgery. As has been stressed before, this series of proved cases have had every form of conservative and operative treatment tried, including belts, braces, jackets, corsets, fasciotomy, sacro-iliac fusion, etc. The point that is not known is how many additional cases of protruded disc were saved from surgery by such treatment. Manipulation of the spine in suspected disc cases is strongly condemned. It may result in paraplegia.

ANALYSIS OF CASES

Age and Sex. The age of the patients averaged thirty-seven years and ranged from sixteen to sixty-five. Seventy-eight per cent. were males and 22 per cent. females.

History. In 50 per cent. disability occurred immediately following injury and in another 30 per cent. the disability developed after a latent period. In the order of frequency, the most common causes of injury were lifting a heavy weight, falling from a height, and incurring a twisting strain.

Pain. In 60 per cent. the pain was constant from onset until operation, in 40 per cent. there were remissions and relapses. In 30 to 40 per cent. backache preceded sciatica. In 80 per cent. the referred pain was unilateral, and in 20 per cent. bilateral. Ninety-five to 100 per cent. of the patients complained of pain in the posterior and lateral thigh; 90 per

cent., in the posterior and lateral calf; 70 per cent., in the lumbosacral region; 65 per cent., in the gluteal region; and 20 per cent., in the lateral border, sole, or dorsum of the foot, or the great toe.

Physical Examination. Straight-leg raising was limited on the painful side in 95 to 100 per cent., and on the other side in 30 to 50 per cent. Lasègue's sign was usually positive. Sciatic scoliosis was present in 60 per cent. (40 per cent. contralateral and 20 per cent. homolateral). Reversal of the usual lumbar curve (kyphos or flat back) and limitation of motion of the lumbar spine occurred in 90 per cent. There was local tenderness over the lumbar spinous processes at the level of the lesion in 50 to 60 per cent.; radiating pain on coughing, sneezing, percussion of the lumbar spinous processes, or jugular compression in 40 per cent.; and atrophy of the buttock, thigh, or calf in 50 per cent.

Neurological Signs. The ankle jerk was absent or diminished in 70 per cent. Sensory changes in the extremity—most commonly on the lateral calf, lateral border of the foot and fifth toe, and posterior thigh—occurred in 35 per cent. Motor weakness of the dorsiflexors of the foot or the gastrocnemius muscle was present in 15 per cent., and sphincter disturbance in 5 per cent.

Location of the Lesion. The lesion occurred at the third lumbar in two cases; the fourth lumbar in eighty-one; the fifth lumbar in fifty-seven; and the first sacral in one. These figures include two patients who had a recurrence of symptoms and a second operation.

Other Pathology. In twenty-three patients who were operated upon after a preoperative diagnosis of possible ruptured disc, hypertrophy of the ligamentum flavum was found in ten; chronic adhesive arachnoiditis, in eight; hypertrophied ligamentum flavum plus arachnoiditis, in two; hypertrophied ligamentum flavum plus generalized posterior bulge of the disc, in one; and varix over nerve root, in two.

END RESULTS

The two deaths in this series occurred in patients who had preoperative paraplegia from extremely large ruptured discs. Their symptoms did not respond to relief of the pressure. One of them died postoperatively of complicating sepsis. The other one lived five months after operation. Since the death of that patient in 1931, there have been no operative deaths in a series of over 130 consecutive cases.

Of 139 patients with protruded disc in the lumbar spine operated upon at the Massachusetts General Hospital up to January, 1940, ninety-four have been followed for at least one year, and the postoperative result ascertained. The average follow-up period was three and one-half years. Seventy-seven per cent. of the patients have had complete relief from their radiating pain, and an additional 18 per cent. have had only minor discomfort in the affected leg; in other words, the relief from the sciatic pain has been satisfactory in 95 per cent. of the cases. Five per cent. must be classed as failures. In this group are two patients who had

temporary relief from the removal of a ruptured disc. One had a recurrence of symptoms and at a subsequent operation was found to have a recurrent protrusion at the same site. The other patient developed sciatica in the opposite leg, and at a second operation was found to have a ruptured disc at the same level but on the opposite side from the original rupture. Both of these patients have been relieved of their symptoms by the second operations. Thirty-seven patients have been operated upon too recently for end results to be available, and six were untraced.

Back Symptoms. Although laminectomy and removal of the protruding disc fragment is almost uniformly successful in relieving the patient of his major symptom, radiating sciatic pain, there is another factor which has particular interest and which has been studied most carefully, and that is weakness or discomfort in the low back. The authors have found that 60 per cent. of their patients deny having any back symptoms, and consider themselves as strong physically as before the onset of their disability. Thirty-two per cent. complain of slight to moderate back weakness or discomfort, and 8 per cent. consider themselves markedly disabled. In other words, 40 per cent. would probably have had to seek lighter work if their occupation entailed manual labor. As the majority of cases of ruptured discs occur among vigorous young and middle-aged men, even slight to moderate back disability is serious. In the case of the laboring man, it may mean changing from self-support to economic insufficiency, while in others it means curtailing all vigorous sports. There are two probable explanations for the occurrence of a weak, painful back. The mechanical derangement due to the ruptured disc is obvious in certain instances. Roentgenograms may show marked narrowing of the vertebral interspace with accompanying hypertrophic spur formation, and subluxation of the articular facets; and so, although the protruded disc tissue has been removed and the sciatica relieved, there remains a *locus minoris resistentiae* easily susceptible to strain. Secondly, the laminectomy itself may weaken the back to a greater or lesser degree, particularly if sacrifice of an articular facet is necessary. In about one

TABLE II

RELIEF OF SCIATIC PAIN FOLLOWING OPERATION IN NINETY-FOUR PATIENTS FOLLOWED FOR ONE YEAR OR MORE

Results	Whole Series		Spines Fused		Spines Not Fused	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Complete relief	72	77	30	91	42	69
Minor symptoms	17	18	2	6	15	25
Moderate pain	2	2	0	0	2	3
Severe pain	3	3	1	3	2	3
Totals	94	100	33	100	61	100

TABLE III

Residual Back Symptoms Following Operation in Ninety-four Patients Followed for One Year or More

Results	Whole Series		Spines Fused		Spines Not Fused	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Normal back........	56	60	24	73	32	52
Mild weakness or pain	30	32	7	21	23	38
Moderate weakness or pain.............	5	5	1	3	4	7
Severe weakness or pain (pseudarthrosis)..............	3	3	1	3	2	3
Totals..............	94	100	33	100	61	100

out of three cases, the spine has, therefore, been fused. The criteria for fusion have varied with the personal convictions of the surgeon in charge, but in general, if the patient was a laboring man or indulged in active athletics; if, at operation, there seemed to be abnormal mobility of the involved vertebrae; and if the laminectomy was extensive or required sacrifice of an articular facet, fusion was performed. The results in the fused and unfused cases are compared in Tables II and III. Seventy-three per cent. of the patients having fusion considered their backs of normal strength, whereas only 52 per cent. of those without fusion had no complaints. The two patients who had recurrence of the disc protrusions, proved by operation (referred to above), had not had spine fusions done at the time of the first operation, and it is possible that an unfused spine is more likely to have further protrusion of disc tissue than one which is fused.

Ten cases of probable ruptured intervertebral disc with positive lipiodol examination have been treated conservatively. One is free of symptoms; the others have back and leg pain of greater or lesser severity.

There are certain drawbacks to spine fusion. It prolongs the operative time somewhat, subjects the patient to a certain additional operative risk and to a somewhat more prolonged convalescence. This series of cases is as yet too small to allow definite conclusions to be drawn, but there is a place for spine fusion at the time of laminectomy in perhaps 20 to 30 per cent. of the cases of protruded intervertebral discs.

The end-result study of twenty proved cases, in which there was compensation involved and the patients' medical expenses were paid by an insurance company, reveals that nine, or 45 per cent., have resumed their original occupation and consider themselves fully recovered. Six, or 30 per cent., are at work at lighter jobs. Five, or 25 per cent., are still receiving compensation or have litigation pending and consider themselves

disabled. Three additional patients have had recent operations, and the result cannot yet be determined. The fact that 75 per cent. of these cases have returned to some type of work leads to the belief that there is justification in expecting cooperation from insurance companies in the attempt to rehabilitate otherwise totally incapacitated patients.

There is a serious dilemma facing the medical profession with regard to who shall treat these cases, and although the situation has been discussed verbally, little has been put into writing. The neurosurgeon and the orthopaedic surgeon each have an interest in the situation. The neurosurgeon by reason of training, experience, and skill in handling nerve tissue is in general better equipped to perform the laminectomy than the average orthopaedic surgeon. However, he has had little or no experience in the recognition and conservative treatment of mechanical low-back disabilities, in the indications for and technique of spine fusion, and in supervision of the muscular rehabilitation exercise program which is so necessary in the postoperative care of the patients. The orthopaedic surgeon, by virtue of his training, has these qualifications. Who then shall care for cases of protruded intervertebral disc? It would seem that a competent orthopaedic surgeon should be placed in charge of every case of chronic mechanical low-back disability with or without sciatica. If conservative treatment fails or seems to him inadvisable, he should then call in consultation a neurosurgeon before lipiodol roentgenography or other complicated investigative procedures are initiated. The decision as to whether myelography is indicated, whether spine fusion should be done at the time of laminectomy, and so on, is discussed after the neurosurgeon has made a thorough examination of the patient. If spine fusion is indicated, the orthopaedic surgeon should join the operative team and do this part of the operation. He should also supervise the program of postoperative exercises designed to restore the patient's physique to normal.

SUMMARY AND CONCLUSIONS

Posterior protrusion of one of the lumbar intervertebral discs into the spinal canal is one of the most common mechanical derangements of the low back in patients suffering from intractable sciatic pain. The leg pain is due to direct pressure of the displaced intervertebral-disc tissue on one or more roots of the cauda equina. In addition to this lesion, there may be found associated thickening of the ligamentum *flavum*, chronic adhesive arachnoiditis, hypermobility of the involved vertebrae, and oedema of the involved nerve roots. Although the etiology of posterior disc protrusions is not perfectly clear, trauma to and degenerative changes in the intervertebral discs alone or in combination seem to be the usual causes of posterior protrusion.

Among the most common and characteristic symptoms and signs, are intractable sciatic pain following a lifting injury, accompanied by limitation of back motion and of straight-leg raising, sciatic scoliosis, and lumbar kyphosis, tenderness over the lower lumbar spinous processes, and

absence of the ankle jerk. The total protein of the spinal fluid is usually elevated. There are no changes on the routine roentgenograms characteristic of ruptured intervertebral discs, but narrowing of the fourth lumbar disc is of some importance if the clinical picture is characteristic. Lipiodol examination is highly accurate in making the correct diagnosis and in localization of the lesion, but because of potential danger, the use of lipiodol should be reserved for cases in which surgery is necessary. Pneumomyelography and clinical localization of the lesion may make the use of lipiodol necessary in not more than one-half the cases. Conservative treatment should be tried in every case of suspected protrusion of the intervertebral discs unless there is obvious serious nerve-root pressure, as shown by objective sensory or motor disturbance. Bed rest and immobilization of the lumbar spine in a plaster jacket seem to be the most effective means of conservative treatment.

Surgical treatment consists in the removal of the ruptured disc fragment through as small a laminectomy incision as possible. Spine fusion at the time of the laminectomy seems to give definitely better results than laminectomy alone.

Of ninety-four cases of proved ruptured intervertebral disc followed for at least one year after operation, 77 per cent. had complete relief of sciatic pain, and an additional 18 per cent. had only minor leg pain. There were two proved cases of recurrent ruptures in this series.

The relief of back symptoms was not as satisfactory as the relief of the radiating leg pain. Seventy-three per cent. of the patients in whom the spine was fused and 52 per cent. of the patients without fusion had no back symptoms. The rest had complaints of backache or weakness of varying severity. In a small series in which insurance compensation was involved, 45 per cent. of the patients have been returned to their original occupation.

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SPINE FUSION FOR PROTRUDING INTERVERTEBRAL DISCS

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During the six years since Mixter and Barr published their first work on protrusion of the intervertebral disc as a cause of low-back pain and sciatica, there has been a growing consciousness of this condition and a growing use of laminectomy in its treatment. The literature on the subject very often suggests that the clinical picture is typical, the diagnosis easy and definite with or without lipiodol or air myelography, and that the only treatment to be considered is laminectomy with the removal of the offending portion of the intervertebral disc.

Certainly if protrusions of the intervertebral disc are common today, due to tears of the annulus fibrosus or actual herniation of the nucleus pulposus, they must have existed to the same extent before the last six-year period. If these protrusions cause symptoms today, they must have caused the same symptoms in the past and driven patients to the medical profession.

Before the era of recognition of disc protrusion, these cases would have been, in the most part, indistinguishable from cases of low-back pain and sciatica attributed to disturbances at the lumbosacral or sacro-iliac joints. At the New York Orthopaedic Dispensary and Hospital the sacro-iliac joint has not been considered a common cause of this syndrome, and the condition has been explained in most cases on the basis of instability or mechanical inadequacy of the lumbosacral joint.

In the years from 1914 to 1936 inclusive, those patients who were operated upon for low-back pain and sciatica were treated in the main by lumbosacral fusion. Since the development of the Ober fasciotomy in 1934, this procedure has been used, with or without spine fusion, but to a less extent than fusion alone. In 1937 laminectomy combined with fusion, and occasionally laminectomy alone, was done in cases where there seemed to be sufficient evidence of intraspinal pathology.

To date there have been thirty-three laminectomies. In three of these no pathology was found. The other thirty included ten protrusions of the intervertebral disc, five cases of hypertrophy of the ligamentum flavum, one extradural scarring, two neurinomata, one varicosity along a nerve root, and eleven cases of adhesive arachnoiditis. Four cases of protruding disc and two cases of hypertrophy of the ligamentum flavum had arachnoid adhesions as well.

This variety of conditions, not specifically diagnosed before operation, is evidence of the difficulty in accurate clinical diagnosis of intraspinal lesions. In most of these conditions, spinal puncture, with manometric

and total-protein determinations, is of very doubtful differential value. One case, an inoperable neurinoma of the cauda equina, showed a *total-protein* content of 250 milligrams per 100 cubic centimeters above the level of the lesion, and xanthochromic fluid was obtained from the lesion itself. In the other cases there was no evidence of block, and the protein determination gave no indication of the type of pathology later found at operation.

TABLE I

RELATION OF TOTAL SPINAL-FLUID PROTEIN TO PATHOLOGY FOUND AT OPERATION

Pathology	*Cases*	Total Spinal-Fluid Protein (*Mg. per 100 c. c.*)
Disc protrusions without adhesions	10	58
All disc protrusions (4 with adhesions)	14	64
Adhesions alone	11	68
All with adhesions	17	68
All without disc protrusion or tumor	18	68
No pathology	3	61

Satisfactory myelography would do much to establish a definite diagnosis, but the authors have not found air myelography satisfactory, and they consider lipiodol too potentially harmful a substance to be employed.

There may very well be cases of true compression of the nerve roots by protruding intervertebral discs, and certainly sciatic pain is occasionally associated with new growths within the spinal canal, but the greatest number of the authors' laminectomies revealed arachnoid adhesions between the nerve roots, or a disc protrusion small enough to allow the nerve roots adequate passage. They found only one large herniation, 1 by 1.5 by 2.0 centimeters, apparently causing considerable nerve-root compression.

It has not been proved that a disc protrusion which merely angulates one or more nerve roots can cause symptoms in the absence of motion. Certainly the nerve roots are normally angulated about many structures in their normal course, and the spinal cord itself is often severely angulated at a tuberculous kyphos without the production of any nerve symptoms.

If the small disc protrusions cause nerve-root symptoms, it is much more reasonable to believe they do so by repeated sliding of the nerve over this protrusion with spine motion, than that they actually compress a nerve which is free to move away from the protrusion.

It is even more reasonable to believe that the small disc protrusion may often be an inconsequential element of a grossly unstable mechanical system. The stability of the lumbosacral joint depends not entirely on any one feature of its structure, but upon the composite of several elements and their relationship. The nature of the arch articulations, the angle of the superior surface of the sacrum, the presence or absence of impinging spinous processes, and of anomalies such as partial sacralization of the fifth lumbar vertebra, as well as degenerative changes, must all be

considered. A small disc protrusion, occurring in 15 per cent. of Beadle's series of spines, would seem to be merely another factor to be considered in relation to the others.

Radicular pain resulting from a fractured vertebra or arthritic lipping with pressure on the nerve roots has long been known to be amenable to immobilization by bed-rest, or spontaneous or surgical fusion.

Before the era of laminectomy for sciatic pain, most of the cases of protruding disc and arachnoid adhesions were undoubtedly fused. Either these patients were cured by fusion or must still have their pain, and present neurological signs. Those who had intraspinal pathology of any nature should be found largely among those patients who had neurological signs before fusion.

A study has been made of 175 cases treated by lumbosacral fusion for typical sciatic pain. Neurological examinations in this group were often omitted or inadequately done before the possibility of protruding discs was known. However, forty-six patients were found who had some or all of the abnormal neurological signs, now commonly attributed to protrusion of an intervertebral disc.

These forty-six patients include those with but few neurological signs, as well as those in which there was a fairly typical picture of nerve-root compression, as evidenced by unilateral calf atrophy, weakness of the anterior tibial and peroneal muscles, absence of the ankle jerk, and sensory loss in the lateral calf. Some have had even more marked changes, with complete foot-drop. It has been possible to see twenty-seven of these patients for this study and they have been compared with twenty-one of those who had had laminectomy fusions.

The results in the group with spine fusions were almost the same as the results in the group with laminectomy fusions.

TABLE II

RESULTS OF OPERATIVE TREATMENT FOR SCIATIC PAIN

Treatment	*Cases*	Average Relief of Pain (*Per Cent.*)	75–100 Per Cent. Relief of Pain (*Per Cent.*)
Fusion	27	85	83
Laminectomy-fusion	21	84	87

Five patients have had laminectomy following fusion. Of these, one had a protrusion of the intervertebral disc above the fusion, two had arachnoid adhesions, and one had extradural scarring. The fifth had laminectomy done in spite of a pseudarthrosis of the original spine fusion, because the neurological signs were not thought attributable to a pseudarthrosis alone. No intraspinal pathology was found in this case. In these five cases there was none with any appreciable improvement following laminectomy.

An examination of the reontgenograms of the thirty-three patients who have had laminectomy, revealed twenty-seven lumbosacral joints

classified as severely unstable; five as mildly unstable; and one as stable. This last patient had the large disc protrusion previously mentioned.

A comparison with a group of cases fused for sciatica, without any abnormal neurological signs, shows very little difference in the roentgenographic findings of the two groups; nor is there any outstanding roentgenographic difference between the laminectomy cases where a protruding disc was found and those where it was not found.

In summary, the diagnosis of protruding intervertebral disc is not one easily made. Clinical examination, spinal puncture, roentgenograms, and air myelograms have, in the authors' hands, been ineffectual in establishing an accurate diagnosis. Further, spine fusion alone has accomplished in many cases, which were clinically indistinguishable from protruding-disc cases, as good results as laminectomy and spine fusion with the removal of the disc protrusion. Theoretically, the majority, if not all, of the cases of protruding intervertebral disc can be relieved by fusion alone.

The authors submit that the need for laminectomy in treating protruding intervertebral disc has never been established. They present presumptive evidence that spine fusion alone is as effective as laminectomy and fusion, and suggest that fusion alone, a theoretically sound procedure, may be the treatment of choice.

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NOTE

The paper on Sacro-Iliac Conditions presented by Marius N. Smith-Petersen, M.D., as part of the Symposium has not been received for publication.—*The Editor.*

LOW BACKACHE AND SCIATIC PAIN ASSOCIATED WITH SPONDYLOLISTHESIS AND PROTRUDED INTERVERTEBRAL DISC: INCIDENCE, SIGNIFICANCE, AND TREATMENT

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The occurrence of sciatic pain associated with spondylolisthesis will become of increasing significance, will influence diagnosis and treatment, and will once more demonstrate the importance of cooperation among the roentgenologist, neurologist, and orthopaedic surgeon. Low backache is the most common symptom of spondylolisthesis, and it is equally, if not more, common among patients who have protrusion of an intervertebral disc. Sciatic pain, on the other hand, is common among those patients who have protrusion of an intervertebral disc, and occurs among only a small percentage of the patients suffering from spondylolisthesis. Although it is true that knowledge of the incidence of sciatic pain in the presence of spondylolisthesis is very limited, recent developments have shown the need for careful consideration of the possibility of a coexisting protrusion of an intervertebral disc causing the sciatic pain. At The Mayo Clinic the diagnosis of protrusion of an intervertebral disc, causing sciatic pain, has been made in patients for whom a diagnosis of spondylolisthesis with backache also had been made, and in whom the findings at operation substantiated such diagnosis.

To determine the incidence of low-back pain and sciatica among patients suffering from spondylolisthesis, histories have been reviewed of 745 patients for whom such a diagnosis was made from 1918 to 1939 inclusive. Eighty patients, or 10.7 per cent., were found who were so afflicted. A much larger percentage of patients suffering from spondylolisthesis had vague referred pain and paraesthesia of the buttocks, hips, and thighs that were aggravated by activity, such as hard labor, standing for long hours at a time, or injury. The majority of the eighty patients who had associated sciatic pain were referred to the Section on Neurology for further investigation, because the orthopaedic surgeon thought that, from the degree of the symptoms, possibly other factors were involved than those in his diagnosis. The truth of this suspicion became evident as knowledge regarding the etiology of spondylolisthesis and its complications became greater. Table I demonstrates that sciatic pain is more common among males than females—78.8 per cent. to 21.2 per cent.—and occurs most frequently during the years of active life. Seventy-seven and five-tenths per cent. of the instances of sciatic pain occurred among patients between the ages of twenty and fifty years. The average age of these patients was 41.1 years; the average age of the males was 40.2 years ranging from fourteen to seventy-three; the average age of the females was 44.2 years, ranging from twenty-one to eighty.

TABLE I

INCIDENCE BY SEX AND AGE OF SPONDYLOLISTHESIS WITH BACKACHE AND SCIATIC PAIN

Age by Decades, (*Years*)	Total Patients		Male		Female	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
0– 9........	0	....	0	....	0	....
10–19........	1	1.2	1	1.6	0	....
20–29........	19	23.8	15	23.8	4	23.5
30–39........	26	32.5	23	36.5	3	17.6
40–49........	17	21.3	12	19.0	5	29.4
50–59........	11	13.8	8	12.7	3	17.6
60–69........	4	5.0	3	4.8	1	5.9
70–79........	1	1.2	1	1.6	0	....
80–89........	1	1.2	0	....	1	5.9
Total....	80	100.0	63	100.0	17	100.0

Trauma is an important medicolegal question in the presence of sciatic pain. Frequently the causation of a disabling sciatic pain is difficult to ascertain, and the employee and employer look to the physician for advice in settling compensation claims. When spondylolisthesis complicates the clinical picture, the question is even more perplexing and taxes the diagnostic ability of the most expert physician. As a rule, patients who have low backache and sciatic pain associated with spondylolisthesis have had symptoms for years; some had backache at the time of onset, and later began to suffer from acute sciatica following a strain or injury; others had no definite single incidence of trauma, but were engaged in occupations that entailed strenuous exertion. In a previous publication[1], the author has shown that in about 10 per cent. of the cases in which a diagnosis of spondylolisthesis had been made, the patient did not complain of pain referable to the back, and that the diagnosis was made incidentally during the routine physical examination or during roentgenographic examination of other parts of the body. Because the usual backache and paraesthesia found in association with spondylolisthesis are as a rule relieved by rest and aggravated by work, these conditions have often led to the opinion that the patient was a malingerer. When the picture is confused by sciatic pain following strain or injury, intraspinal pressure must be considered.

The author believes that patients afflicted with spondylolisthesis are more likely to have protrusion of an intervertebral disc than are those who have a more stable spinal column. Trauma is a definite factor in

TABLE II

GRADE OF SPONDYLOLISTHESIS WITH BACKACHE AND SCIATIC PAIN IN RELATION TO HISTORY OF TRAUMA

Grade	Trauma		No Trauma		Total	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
1	28	65.1	21	56.8	49	61.2
2	13	30.2	11	29.7	24	30.0
3	2	4.7	3	8.1	5	6.3
4	0		2	5.4	2	2.5
Total.	43	100.0	37	100.0	80	100.0

this condition. In this series of eighty patients, forty-three, or 53.8 per cent. had a history of trauma. Eleven of the seventeen classified as having suspected protrusion of a disc gave a history of trauma. These eleven constituted 25.6 per cent. of the forty-three who had a history of trauma, and 65 per cent. of those suspected of having a protruded disc. The remaining six patients constituted only 16.2 per cent. of the thirty-seven who gave no history of trauma. It is the author's opinion that fusion of the lumbosacral region is desirable in those cases of spondylolisthesis, with symptoms of protruded disc in which the surgeon is unable to demonstrate the disc at the time of the operation. This fixation of the spinal column will prevent movement and slipping, and is the most certain method of preventing additional symptoms of backache and sciatic pain.

TABLE III

INCIDENCE AND LOCATION OF SCIATIC PAIN IN RELATION TO GRADE OF SPONDYLOLISTHESIS

Spondylolisthesis, Grade	Total Patients		Location					
			Right		Left		Bilateral	
	No.	Per Cent	No	Per Cent	No.	Per Cent	No.	Per Cent.
1	49	61.2	23	58.9	17	68.0	9	56.2
2	24	30.0	12	30.8	7	28.0	5	31.2
3	5	6.3	3	7.7	1	4.0	1	6.3
4	2	2.5	1	2.6	0		1	6.3
Total.	80	100.0	39*	100.0	25†	100.0	16‡	100.0

* 48.8 per cent. of total of eighty cases
† 31.2 per cent. of total of eighty cases
‡ 20.0 per cent. of total of eighty cases

TABLE IV

COMPARATIVE INCIDENCE OF DIAGNOSIS OF PROTRUDED INTERVERTEBRAL DISC IN EIGHTY OUT OF 745 SPONDYLOLISTHETIC PATIENTS WITH SCIATIC PAIN AND BACKACHE SEEN FROM 1918 TO 1937, INCLUSIVE, AND FROM 1938 TO 1939, INCLUSIVE

Years	Cases	Suspected Protruded Disc	
		Number	Per Cent.
1918 to 1937	55	2	3.6
1938 to 1939	25	15	60.0
Total	80	17*	21.3

* 2.3 per cent. of 745 spondylolisthetic patients. Six of the seventeen, or 0.8 per cent. of 745 cases with suspected protruded discs, were operated upon.

The most common spinal anomaly which this study revealed was separation of the neural arch which was noted in twenty-nine patients, or 36.3 per cent. Evidence of spondylitis or hypertrophic changes was noted in thirteen, or 16.3 per cent., and of sacro-iliac arthritis in three, or 3.8 per cent. of the roentgenograms of the spinal column.

The incidence and location of sciatic pain in comparison to the grade of spondylolisthesis are presented in Table III. It is interesting to note that pain in 91.2 per cent. of all cases, and 89.7 per cent. with sciatic pain on the right side, occurred in the presence of Grades 1 and 2 of spondylolisthesis, the lesser degrees of displacement. In the cases in which the condition was bilateral, 87.4 per cent. of instances of pain occurred in Grades 1 and 2. Marked displacements (as represented by Grades 3 and 4), are accompanied by fewer, not, as might be expected, more complaints, than are the lesser grades, indicating that there may be some factor other than spondylolisthesis involved in the production of the sciatic pain (Table III).

The significance of sciatic pain which is associated with spondylolisthesis was discussed at The Mayo Clinic when operations for protrusion of intervertebral discs were begun. Investigation of this latter condition soon made it evident that suspicions were justified. A thorough neurological investigation, including spinograms, is now a routine procedure for those patients with sciatic pain for whom the diagnosis of spondylolisthesis has been made. This is especially emphasized for those who have diminution or loss of the Achilles reflex, with pain, numbness, or paraesthesia. As a result of cooperation between the roentgenologist, neurologist, and orthopaedist, the incidence of protruded intervertebral discs diagnosed in association with spondylolisthesis with sciatic pain has increased enormously since 1937 (Table IV).

Figures 1*a*, 1*b*, 2*a*, and 2*b* demonstrate why forward slipping of the body of a vertebra alone will not cause impingement on the nerve roots.

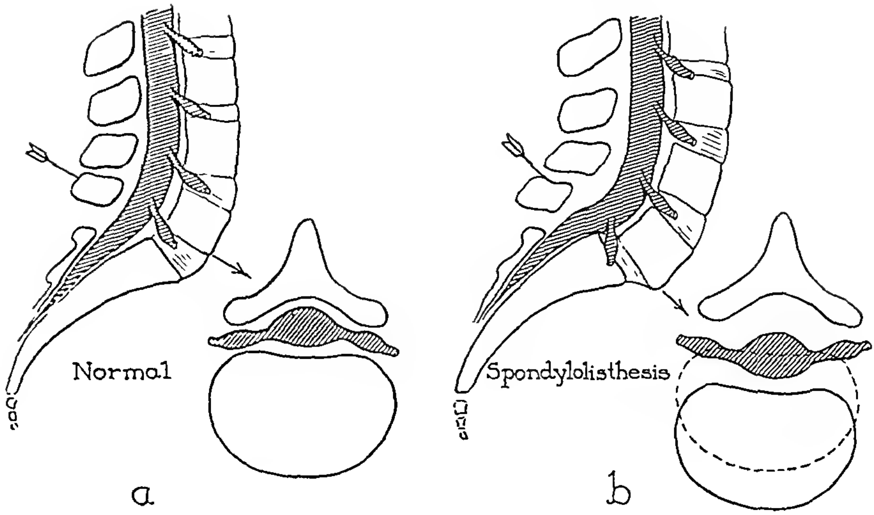

FIG. 1

Fig. 1*a*: Schematic drawing illustrating the normal relationship of the cauda equina and spinal column. On the right is a cross section of the spinal column in the lumbosacral region, showing ample space about the spinal cord.

Fig. 1*b*: The relationship of the cauda equina and spinal column in the presence of spondylolisthesis, grade two. On the right is a cross section of the spinal column in the lumbosacral region, showing the relationship of the spinal cord to the surrounding structures in the presence of spondylolisthesis, grade two.

The neural arch remains behind and, although the cauda equina and roots may be slightly stretched, there is enough room, in the large spinal canal, to prevent direct pressure on the cauda equina. In patients with the congenital types of spondylolisthesis, and in those in whom development was slow, there is rarely any paralysis, because nature compensates for stretch and pull. In the cases in which the injury is acute and severe,

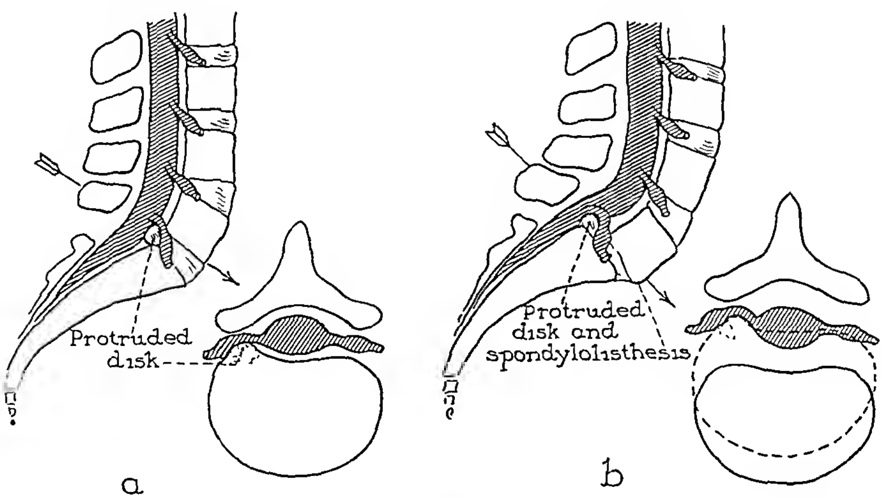

FIG. 2

Fig. 2*a*: Schematic drawing illustrating a protruded intervertebral disc without spondylolisthesis.

Fig. 2*b*: Protruded intervertebral disc in the presence of spondylolisthesis.

with fracture or rotation of a vertebra or vertebrae, it is obvious that evulsion of nerve roots, pressure of bone fragments, hematomata, and paralysis of the caudal segments may occur. Thus, it would seem that the common symptoms of spondylolisthesis, such as backache, pain, and paraesthesia referred to the buttocks and legs, are the results of instability of the lower portion of the spinal column with subsequent irritation and strain, rather than the results of direct pressure. The protruded disc, on the other hand, may cause direct pressure on the nerve roots. When the protrusion occurs in the center, bilateral distribution of pain may result, but when the protrusion is to the side, pain arises from the corresponding nerve-root distribution and sciatica results.

Conservative treatment of patients suffering from sciatic pain in the presence of spondylolisthesis, consists of rest by recumbency, use of external appliances and physical therapy measures, such as the application of heat and medication. Elevation of the flexed legs with traction so that the body is partially suspended, fixation in a plaster cast, or traction by means of double Buck's extension, and a firm bed, may aid in giving the patient comfort. Patients have been seen for whom all means of combating the backache and sciatic pain had failed, for whom conservative measures had been initiated without relief, and the author is, therefore, firmly convinced that such measures are of little permanent value. In spite of accurate diagnosis and explanation as to the cause of a patient's disability, there will always be those who refuse surgical treatment and who will have to be treated conservatively. The lumbosacral corset with reinforced steel stays, when worn persistently, and local applications of heat, are, when they are combined with medieation, perhaps the most efficient non-surgical measures. In the present series of eighty patients, who had spondylolisthesis associated with a sciatic pain, conservative measures were carried out for forty-nine, or 61.3 per cent.; surgical fusion was performed for twenty-five, or 31.3 per cent.; and surgical fusion with removal of a protruded intervertebral disc was performed for six, or 7.5 per cent.

To insure relief of the sciatic pain and backache associated with spondylolisthesis, treatment must consist of immobilization of the lumbosacral region and relief of intraspinal pressure. At the Clinic, insertion of bone grafts alone in an attempt to relieve sciatic pain in such cases is not considered sufficient. Removal of the protruded disc combined with the added safeguard of lumbosacral fusion is the method of choice. The results from such a procedure have proved to be encouraging in the limited instances in which the patients have accepted this form of surgical treatment. There is no doubt that some of the patients may obtain a measure of relief from surgical fusion alone. The author believes, however, that such benefit would be partial only and never complete, and that the danger of recurrence of symptoms, the hazards of secondary operation, and the delay of prolonged disability would make it advisable to remove pressure from the nerve root in every patient with a proved

protrusion of an intervertebral disc. In the past this complication of spondylolisthesis was not recognized, and no doubt some patients who underwent the operation of spinal fusion, and received partial relief of symptoms, still have the offending discs that cause continued suffering.

A combined operation, the technique of which consists of laminectomy with removal of the protruded disc, and fusion of the lumbosacral portion of the spinal column, has given gratifying results. It is usually performed with the patient under spinal or general anaesthesia and requires two surgical teams. While the neurological surgeons remove the discs, the orthopaedic surgeons remove from the tibia the sections of bone for grafting. The time consumed in this first stage permits the immediate insertion of the grafts into the lumbosacral region and thus saves the patient an unusually long period of surgical treatment. In this procedure the neurosurgeon prepares the bed for the grafts and performs the laminectomy. Should there be considerable defect in the lamina, following the removal of the disc, the surgeon may use a graft of periosteum, sutured so that it covers the defect. To insure a strong bony support, two grafts are usually inserted, together with numerous fragments and cancellous bone that have been removed with a curet from the upper end of the tibia. The sides of the spinous processes, lamina, and facets are further roughened with a chisel or curet to insure bony approximation and ultimate fusion. The region which is usually fused consists of the third, fourth, and fifth lumbar, and the first two sacral vertebrae. The resultant mass of bone is the most secure fixation of the lumbosacral region that the author has been able to devise, and results from an application, with modifications, of the principles of fusion brought out by Albee and Hibbs. Roentgenograms taken subsequently show bony fixation. At the end of two weeks, during which time the patient has been kept recumbent and turned over three to four times a day, the incision is inspected and the stitches are removed. The patient is kept in bed for six to eight weeks following operation, and then is advised to wear a steel, reinforced, lumbosacral corset for six to eight months. A period of a year will elapse before the patient makes a maximal improvement, although there are some cases in which the patient is able to return to his usual occupation in much less than a year. When it is necessary for the patient to return home or to be moved some distance in less than six to eight weeks, a double plaster spica cast, applied so that it extends well up on the chest, will make this possible without much danger.

REPORT OF CASES

Case 1. A man, aged forty-four years, reported to the Clinic on May 11, 1939, complaining of low backache, recurring shooting pain extending down the left leg, and foot-drop. About twenty-six years prior to his admission, he had often experienced, in athletic work, periodic pain in the back that sometimes shot down the left leg. This condition had continued to be aggravated by walking. He had been treated for arthritis. Five years prior to his admission an accident had aggravated the condition and two years later he had noticed progressive foot-drop developing. In spite of various treatments

and recumbency for a period of months, he was disabled and the pain had become progressively worse.

Examination revealed spondylolisthesis, grade one, of the third lumbar vertebra on the fourth, spondylitis with lipping, and left foot-drop; and absence of the Achilles and the external hamstring reflexes on the left, and of the Kernig and Lasègue signs. Examination of the spinal fluid, done elsewhere, had revealed a protein content of 71 milligrams per 100 cubic centimeters.

A left laminectomy, performed with the patient under spinal anaesthesia, revealed a large protruded intervertebral disc at the level of the fourth interspace, and marked hypertrophy of the ligamentum flavum. The protruded disc and the hypertrophied portion of ligamentum flavum were removed. The nerve root was found to be stretched over the disc and was swollen to about three times its normal size. A tibial graft and multiple bone chips were inserted to obtain fusion. The patient left the hospital on the fifty-first postoperative day, relieved of sciatic pain and wearing a lumbosacral support. He has had an uneventful convalescence, to the time of this writing.

Case 2. In a previous publication, and in the exhibit presented before the American Academy of Orthopaedic Surgeons at the time of the meeting in Boston in January 1940, the author reported the case of a man, aged thirty-five, on whom he had operated for backache and left sciatica. A diagnosis of spondylolisthesis, grade one, of the fifth lumbar vertebra on the sacrum, and of protrusion of an intervertebral disc, was made. The protruded disc and hypertrophied portion of ligamentum flavum were removed, and a bone graft was inserted to produce fusion of the third, fourth, and fifth lumbar, and the first two sacral vertebrae. In this case the protruded disc had migrated from the fourth interspace to the lumbosacral region, and the fifth lumbar nerve had been stretched over it and become thickened.

Case 3. A farmer, aged twenty-five, was admitted to the Clinic on June 19, 1939, complaining of backache with pain in the right leg. He stated that two years prior to his admission he had fallen twelve feet and landed on the buttocks. Following the accident he had experienced severe pain in the region of the coccyx, which disappeared in about two weeks. Four months prior to his admission, while engaged in heavy labor, the patient began to experience an aching pain in the lumbar region of the spinal column, which was aggravated by bending, lifting, weight-bearing, coughing, and sneezing, and which interfered with his sleep. Six weeks prior to his admission, sciatica developed on the right side, became severe in character, and extended into the heel. Furthermore, the patient began to lose weight rapidly, losing fifteen pounds (seven kilograms) altogether.

Examination revealed tenderness over the region of the fourth and fifth lumbar vertebrae, a positive Lasègue's sign, absence of the Achilles reflex on the right, and a total protein content in the cerebrospinal fluid of 35 milligrams per 100 cubic centimeters. There was an obvious depression of the lumbar portion of the spinal column, and some muscular spasm in the lumbar region with limitation of flexion. The roentgenograms revealed spondylolisthesis, grade one, with separation of the neural arch.

Following neurological and orthopaedic consultation, a diagnosis of spondylolisthesis with protrusion of intervertebral disc was made. The patient was advised to undergo laminectomy for removal of the disc, and bone graft for production of fusion of the lumbosacral region of the spinal column. He preferred to have conservative measures carried out first, and was sent home with a well-fitted lumbosacral corset.

The patient returned in about five weeks, and a right hemilaminectomy of the fifth lumbar vertebra was performed on August 3, 1939. A thickened ligamentum flavum and a huge classic protrusion of the lumbosacral disc were found. The latter was attached to a fibrous string of cartilage about 5 centimeters in length, thus relieving pressure on the nerve. Following the removal of the disc, a double bone graft was placed on either side of the spinous processes to produce fusion of the fourth and fifth lumbar and the first two sacral vertebrae. Multiple bone chips were packed around these grafts.

Convalescence was uneventful and the patient left the hospital on the forty-ninth postoperative day, wearing a lumbosacral support. The incision was healed, and roentgenograms showed the graft to be in good position. Seven months following the operation the patient apparently had made an excellent recovery.

CASE 4. A man, aged thirty-seven, was admitted to the Clinic on November 29, 1937, complaining of sciatic pain on the right side, of four months' duration, which had been aggravated by activity, and relieved by rest and flexion of the thighs on the trunk. Twenty-seven years prior to his admission the patient had fallen and injured the coccyx. Following the accident he had been treated for "rheumatism" of the left leg. This condition gradually disappeared. Since the onset of his symptoms, he had lost fifteen pounds (seven kilograms).

Examination revealed sciatic pain on the right side, and dental, tonsillar, and prostatic infection. The patient was advised to receive treatment for these conditions. Nine months later he again returned to the Clinic for examination because his pain had increased in severity in spite of the conservative measures that had been carried out. He still obtained relief following rest and flexion of the thighs on the trunk. The pain, which had been rather constant, was more marked on the right side, was aggravated by exertion, and noticeable across the right iliac crest and over the lateral aspect of the right calf. The lumbar portion of the spinal column was flattened, and there was muscular spasm, limited motion, and limitation of leg raising on the right. The protein content of the cerebrospinal fluid was 50 milligrams per 100 cubic centimeters. A diagnosis of protrusion of an intervertebral disc between the fourth and fifth lumbar vertebrae on the right, spondylolisthesis, grade two of the fifth lumbar vertebra on the sacrum, was made. Results of urinalysis and the reaction of the flocculation test were negative, and the blood count was within normal limits.

On December 6, 1937, excision of a small portion of the right lamina of the fourth and fifth lumbar vertebrae was carried out. The ligamentum flavum, which was hypertrophied between the two vertebrae was removed. The nerve had been displaced posteriorly by the protruded underlying disc. The nerve root was dissected out and the disc removed, which relieved pressure on the nerve. A bone graft was inserted to produce fusion of the fourth and fifth lumbar and the first two sacral vertebrae. Convalescence was uneventful. The patient was provided with a lumbosacral support.

CASE 5. A chauffeur, aged thirty-three, was admitted to the Clinic on November 7, 1938, complaining of recurring pain in the back and left leg of eleven months' duration. Instantly following a heavy blow in the left side of the lower part of the spinal column, he had experienced terrific pain, and on the day following, pain had occurred over the sacro-iliac region. This pain had lasted for several days, and later had extended down the left leg. It had been aggravated by coughing, sneezing, walking, standing, or lying down. He was most comfortable when sitting down. Results of roentgenograms, taken at that time, were reported to be negative. He had received physical therapy administered by a cultist. A week prior to his admission he had suffered from some form of infection, and had been told that he had a congenital defect in the spinal column.

Examination revealed a man of normal weight with normal blood pressure, pulse rate, and temperature. There was definite limitation of motion of the spinal column, with tenderness over the left sacro-iliac region, absence of the Achilles reflex on the left, and diminution of the knee and ankle jerks.

Following orthopaedic and neurological consultation, the patient was advised to undergo an operation, which was performed on November 16, 1938. A left hemilaminectomy revealed spina bifida with defect of the neural arch and a grade-one spondylolisthesis. The neurosurgeon noticed a posterior displacement of the first sacral vertebra, which was of a greater degree than that shown in the roentgenograms. There was a protruded disc at the fourth interspace, and both the fourth and fifth nerves were enlarged, as though they had been compressed. A bone graft was placed on the right of the spinous processes to produce fusion of the fourth and fifth lumbar and the first two

sacral vertebrae. The convalescence was uneventful and the patient left the hospital on the forty-ninth postoperative day. Subsequent roentgenograms revealed good position of the graft. About four months after the patient left the hospital he fell. This fall was followed by backache, limited to the region of the operation. No other symptoms occurred, and the pain disappeared in about two weeks. He had had no additional trouble with sciatic pain, and his general condition had improved. He was advised to continue to wear the lumbosacral support. He reported for observation May 23, 1939, and wished to return to work. He was advised to resume his usual occupation gradually and reported in June, 1939, that he had done so.

SUMMARY AND CONCLUSIONS

In the past two years the author has been impressed by the number of cases in which the patient had spondylolisthesis associated with sciatic pain and protrusion of an intervertebral disc. Protrusion of an intervertebral disc was diagnosed in fifteen of the twenty-five cases in which spondylolisthesis was associated with sciatica, and the diagnosis was confirmed in six cases in which operation was performed.

The treatment which offers the greatest benefit in the shortest period of disability and longest period of relief is surgical removal of the protruded disc and fusion of the last three lumbar vertebrae with the sacrum.

Cooperation of the roentgenologist, neurologist, and orthopaedic surgeon is essential in determining the exact situation of the lesion involved in the production of the backache, sciatic pain, and spondylolisthesis. Such cooperation has made it possible to diagnose the condition accurately and to give relief to the group of patients whose ailment heretofore has baffled the diagnostic efforts of even the most skilled surgeons.

1. Meyerding, H. W.: Spondylolisthesis with Protrusion of Intervertebral Disk and Hypertrophied Ligamentum Flavum Associated with Multiple Loose Bodies (Osteochondromatosis) of Right Shoulder Joint: Report of a Case. Proc. Staff Meet., Mayo Clin. XIV, 801, 1939.

FASCIOTOMY FOR SCIATIC PAIN

BY FRANK R. OBER, M.D., BOSTON, MASSACHUSETTS

Fasciotomy for the relief of demonstrable fascial contracture of the thigh has its place in the treatment of chronic lame backs and sciatic pain. It should not be considered as a "cure-all", and is to be recommended only after a careful examination has been made and logical conclusions have been reached; otherwise, a helpful procedure will fall into disrepute. This paper contains a report of eighty-six patients from our clinic on whom fasciotomy has been done for the relief of sciatic pain. Practically all of these patients had chronic lame back and in several cases this was of several years' standing. The first patient was operated upon in May 1934, and the last one in January 1940. In thirty-one a bilateral fasciotomy was performed at one operation, in fifteen the bilateral fasciotomy was performed on the two sides at different times. There were forty unilateral fasciotomies,—twenty-seven left, and thirteen right.

In the bilateral fasciotomy group of thirty-one patients, sixteen are perfectly well, thirteen have shown slow, steady improvement, and one is moderately relieved. In the group of double fasciotomies performed at different times, seven patients are well, seven have shown marked improvement, and one is slightly improved. In twenty-seven patients with fasciotomy on the left, twelve have had excellent results, eleven are improved, one slightly improved, and two have received no help. Of the thirteen patients with operations on the right side, six are well, two improved, two slightly improved and three are not improved. In the eighty-six cases, forty-one have shown excellent results, thirty-three improvement, five only slight improvement, and five no improvement. There is no record in two cases.

The first patient had a fasciotomy on the right side in May 1934, and this was followed six months later by a fasciotomy on the left side for meralgia paraesthetica. The patient has remained perfectly well ever since. He had a severe lame back which was cured after the first fasciotomy.

Relief of the sciatica, following operation, may be obtained immediately or after a variable length of time up to a few months. The lame-back symptoms may continue for a longer period. The shortest history of sciatica was six weeks. This patient had such a very severe attack of sciatic pain that he was unable to feed himself. He received marked relief following the operation and was perfectly well in one month. Practically every case gave a history of lame back, and the duration of the lame back and sciatica, in a great many of these patients, covered many years, in some instances more than ten years. The sciatica was not always continuous, but came on or was aggravated when the lame-back condition returned, and usually lasted for months at a time.

TABLE I

RÉSUMÉ OF RESULTS OF FASCIOTOMY FOR PATIENTS WITH SCIATICA FROM MAY 1934 TO MARCH 1940

Treatment	No.	Results					Time Required to Relieve Back Symptoms		
		Excellent	Improved	Slightly Improved	No Improvement	No Record	Longest (*Years*)	Shortest (*Months*)	Majority (*Months*)
Double Fasciotomy at one operation.....	31	16	13	1	0	1	2	4	4–8
Double Fasciotomy at two operations.....	15	7	7	1	0	0	2	3	3
Single Fasciotomy, left	27	12	11	1	2	1	1	2	3–6
Single Fasciotomy, right	13	6	2	2	3	0	1	2	6
Total	86	41	33	5	5	2	2	2	3–8

Two of the group had had sacro-iliac fusion—one single and one double—without relief. Three had had lumbosacral fusions with only temporary relief, and two with no relief. Fasciotomy helped the patient who had had double sacro-iliac fusion. In the single case in which there was a history of sciatica for twelve years, the fasciotomy, which was bilateral and performed six years after the fusion, resulted in complete cure. The three cases of spinal fusion were cured or improved by fasciotomy.

The abduction test was positive in every one of these patients and almost always present on both sides. In several instances, where the test was positive on each side and a unilateral fasciotomy for sciatic pain had been performed without relief, a later fasciotomy on the opposite side gave complete relief. There were a small number of patients who had sciatica later on in the opposite side and these insisted on having the operation on the second side. One of these patients had had recurrent sciatica for ten years and operation stopped his pain within a month. Four years later he had sciatica in the opposite leg for two or three weeks and insisted on the same procedure for that side. There was complete relief within three weeks.

There have been only a few cases with recurrences and these have usually been slight and of temporary duration, and responded to conservative treatment. In one case a ruptured nucleus pulposus was removed and fusion was done. The sciatica returned again and fasciotomy was repeated with relief.

The operation will, if properly performed, relieve a large number of cases of sciatic pain. In some instances there is early relief of the lame-back condition when associated with sciatic pain. It has been found

that the relief of low-back pain, stiffness, and the associated poor posture is often slow. This is probably due either to the fact that the inflammatory condition is slow in clearing up, or that the physiological curves, having been distorted for years by the bad mechanics of abnormal fascial pulls on the pelvis and low spine, do not return to a normal posture quickly. In addition, the spinal curves, in returning to a normal posture, must exert pressure and tension on muscles, fasciae, and ligaments which have not been subjected to normal conditions for years.

A great many of the patients with lame backs improve so rapidly that no protective supports are necessary, but for those who do not recover rapidly, a support for the back is indicated and will hasten recovery.

Fasciotomy is being performed now quite extensively, and many surgeons have a better record of results than the writer. It should not be done indiscriminately for all sciatic pain, because there are often lesions of the back, of the sciatic nerve, or within the spinal canal which cause pain in the sciatic nerve. Each case of sciatic pain must be studied carefully. It is to be remembered that conservative measures will still relieve a large proportion of these patients and should be tried faithfully. On the other hand, if a patient is suffering great pain which appears likely to continue for some time, fasciotomy can be considered a conservative procedure. It will not add to the length of convalescence, can be advocated as a measure for relief, and should be done on that basis.

The operation is now performed as follows: An oblique incision, four to six inches long, is made from the lower edge of the anterior superior spine downward and backward, to a point just above the level of the greater trochanter and just posterior to it. The skin and subcutaneous fascia are separated by clean dissection above, below, and posteriorly, until a strip about two inches in width has been dissected well back over the anterior surface of the gluteus maximus muscle. The fascia is now divided from the anterior superior spine well back over this muscle. The fascia gaps at the incision, and the flaps are dissected off the muscles for about one inch on each side. All intermuscular septa are divided. If there is a positive Ely's sign, the fascia surrounding the sartorius muscle is also divided. All loose tags of fascial tissue must be removed. The length of postoperative time in bed depends on the severity of the back symptoms and the rapidity with which the sciatic pain clears up.

THE RELIEF OF LOW-BACK PAIN AND SCIATICA BY RELEASE OF FASCIA AND MUSCLE

BY CLARENCE H. HEYMAN, M.D., CLEVELAND, OHIO

The introduction of a new method of therapy should be preceded by a scientific approach to the problem at hand, founded upon anatomical and pathological research, and followed, if practical, by experimentation. When stripping of fascia or fasciotomy was proposed by the author in 1934 such an approach had not been made, although the two cases reported then had been in the nature of experiments. These observations were recorded because at that time it was generally accepted that the origin of most cases of sciatic pain was at the lumbosacral or sacro-iliac articulations. Treatment was directed toward relief of strain at these joints, and, when conservative treatment failed, arthrodesis was the common practice. Controversy centered chiefly upon the differential diagnosis between lumbosacral and sacro-iliac lesions, and finally reached an impasse when surgeons fused all three articulations. Manipulative treatment persisted in making its reappearance from time to time, but generally with the idea of correcting a subluxation, for it was usually followed by fixation.

These concepts were so dominant that the title of the author's first paper on fasciotomy was expressed cautiously, "Thoughts on the Relief of Sciatic Pain", for it was akin to heresy to express a belief that an extra-articular superficial focus of irritation could manifest itself in the syndrome of sciatica. At about the same time Freiberg and Ober announced opinions at variance with the then current views, and Steindler shortly afterwards clarified the reflex phenomena of sciatica upon an anatomical basis,—a posterior syndrome. Procaine injections were a natural sequence as a diagnostic aid and a therapeutic measure. Clinical reports, together with the pathological studies by Gratz, point to a sustained interest in the musculo-aponeurotic and ligamentous origin of low-back pain. One need no longer be hesitant in accepting a lesion of these structures as a primary source of irritation.

In discussing the rôle of fascia and ligaments in relation to low-back pain upon the basis of relief following fasciotomy, the author is conscious of being in an awkward position of proposing an operation without sufficient background, and then trying to rationalize it. It is conceded that fasciotomy is on a weak pathological foundation, and it is difficult to be convincing by mere testimonials of relief when many patients with sciatic pain present comparatively few objective signs of disability. Remissions are common, and the frequency of low-back pain as a manifestation of neurosis is recognized. One must be cautious, therefore, in the interpretation of results of operation. Only those patients whom the author has personally studied are included in this paper.

Since posterior stripping has relieved carefully selected cases of low-back pain or sciatica, one must conclude that the source of irritation lay in a superficial focus in ligaments, fascia, muscles, aponeurosis, or at their periosteal attachments. It is difficult to conceive that the operation corrects sacro-iliac or lumbosacral strain, or relieves a direct irritation upon the components of the sciatic nerve. It then becomes necessary to assume that there is a so-called fibrositis, which would appear to be the weak point of this argument, because there is no convincing proof that fibrositis is a pathological entity. Clinical evidence, however, appears so convincing that it deserves a place as one of the three most common forms of rheumatic disease,—atrophic arthritis, hypertrophic arthritis, and fibrositis.

Space does not permit a complete review of the evidence upon which we accept the entity "fibrositis". Our knowledge of the pathology of fibrositis is practically confined to the studies of Stockman in 1920, and few if any have attempted to corroborate or advance his work. It is said that the term signifies an inflammation of the white, fibrous, supporting tissue, and that the inflammation is characterized at first by a low-grade serofibrinous exudate. Later there are fibrous and tendinous contractures or capsular thickenings.

Fibrositis is distinguished from arthritis by persistently negative evidence of intra-articular disease, no systemic manifestations, normal sedimentation rate, and frequent complete remissions. Slocumb tentatively classifies two types,—a primary and a secondary. The primary type is unaccompanied by, and is independent of, any other definite disease, and presumably is attributable to unidentified infections or toxaemia. The secondary type is secondary to arthritis, trauma, or influenza. The present status is well summarized by editorial comment in the *Fifth Rheumatism Review:* "Although the term 'fibrositis' may seem vague to some and the syndrome it implies incompletely understood, application of this term (or one more suitable) . . . seems in order."

Symptoms of fibrositis are muscle tenderness, stiffness, tenderness over insertions, and pain, particularly when the part is put on a stretch. Pain may be accompanied or replaced by a referred pain felt in the area of the skin corresponding to the nerve root which conducts the afferent impulse, and tenderness to deep pressure in the muscles in the same segmental area.

These incomplete and brief generalizations on an extra-articular origin of low-back pain, and the suggestion that a fibrositis is the basis of the irritation, may be helpful in the selection of cases for posterior fasciotomy. It is regrettable that there is no reliable single test or sign. The criteria for operation are as follows:

1. *Chronicity.* In general it must be assumed that the patient is not suffering from an acute fibrositis as these cases usually do well and recover by the conservative measures of protection, physiotherapy, and possibly procaine injections. Operation is reserved for the chronic case

in which persistent symptoms or tension is not relieved by conservative treatment. Hence, only comparatively few of this large group are suitable for operation.

2. *Localized Symptoms.* The focus of irritation must be localized at or immediately surrounding the posterior superior spine or immediately below the posterior third of the crest of the ilium. Local tenderness at periosteal attachments must be differentiated from diffuse muscular tenderness. In other words there must be localized tenderness at the musculo-aponeurotic or ligamentous insertions. There may be, however, pain and tenderness along the segmental distribution,—that is, sciatica.

3. *Tension Pain.* Generally there must be pain on stretching or active contraction against resistance. Any active or passive motion which exerts tension or stretch upon the affected parts is likely to be painful. Passive relaxation is not painful. This implies that forward bending, particularly while the patient is standing, is limited and painful. Lateral bending away from the affected side may cause pain by stretching, and toward the affected side by the tension of active contraction. Straight-leg raising causes local pain and is limited. Passive extension of the lumbar spine does not stretch the posterior structures and must be free and without pain.

4. *Procaine Test.* A positive response of temporary relief following a local and not massive procaine injection should be sought before proceeding with operation. It is not a necessary postulate, however, since it is difficult—at least for the author—to infiltrate the periosteum satisfactorily to block all painful sensations. There were some patients in this series who were not temporarily relieved by local injection of procaine, but who later obtained lasting relief by fasciotomy.

5. *Exclusion of Other Causes of Pain.* A careful study of the patient must be made to be assured, so far as possible, that symptoms are not caused by an intra-articular lesion or another factor recognized as causing similar complaints. A coexisting and asymptomatic hypertrophic arthritis of moderate degree, revealed only by the roentgenogram, is not a contra-indication to fasciotomy. Fibrositis may be secondary and only a part of the entire picture of arthritis, but still be the sole cause of symptoms.

The purpose of the operation is to release tension of ligaments, fascia, and muscles attached to the posterior superior spine and the posterior third of the crest of the ilium. This is done by subperiosteal stripping laterally, medially, and inferiorly, together with division of the sacrospinalis fascia when tenderness or pain is present there. The technique has been described fully in previous papers and will not be repeated here as it has not been modified.

End results also were reported by the author in 1939 before The American Academy of Orthopaedic Surgeons and published. At that time the results of twenty-one cases of posterior fasciotomy were reported with lasting relief in sixteen. Since that paper was prepared five more operations have been done, resulting in complete relief in four. This

makes a total of twenty-six operations with completely satisfactory results in twenty, or 77 per cent., and partial relief in three, or 11.5 per cent. The cause of failure in two of three cases is known. One had a congenital deformity of the sacrum, and the other had a considerable degree of hypertrophic arthritis in the sacro-iliac joint. It is now obvious that neither case was suitable for the operation.

SUMMARY

Fibrositis is a provisionally accepted entity causing low-back and sciatic pain which may be relieved by posterior fasciotomy in selected cases not yielding to conservative treatment.

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THE FASCIAL ELEMENTS IN ASSOCIATED LOW-BACK AND SCIATIC PAIN

BY ALBERT H. FREIBERG, M.D.,* CINCINNATI, OHIO

The explanation of sciatic pain by a physiological method is excessively difficult; perhaps, even, to the extent of proving to be impossible, unless the pain can be definitely associated with an organic lesion involving the nerve or its radicles. Man is the only vertebrate to whom the erect position is the normal and constant one. The anatomical arrangement of the sciatic trunk in relation to the muscles, and, therefore, to the fasciae, is quite different from that of any other vertebrate; and, even in man there is frequent variation to be found in this respect. There is no means of knowing whether any other vertebrate is subject to what is called "sciatic pain". It is known in man by his psychic response, only. Local tenderness is not only an inconstant, but also an unreliable guide to it, and the patient's response is the one means of recognizing whether such pain has been relieved. The only one who knows to a certainty whether he has pain and to what degree, is the patient himself. The surgeon is limited in his judgment by the finding of corroborative physical changes *in loco*, on the one hand, and his appraisal of the patient's emotional and psychic reactions, on the other hand. Furthermore, there are some who will acknowledge that in their own experience there have been numerous instances in which relief from sciatic pain has resulted from non-operative, so-called "conservative", methods in patients whose history and physical examination did not serve to differentiate them from others in whom it was finally deemed necessary to employ operative treatment. The indication for operation was the failure of the conservative method as it had been used. This result was not predictable or the sequence of events would not have been employed.

Additional experience and study with respect to the lesions of the intervertebral discs, as well as inflammatory conditions in fascia and joint capsule, have modified somewhat the author's attitude on this subject, as stated in 1937. The same thing can be said concerning the lesions at the sacrolumbar articulation. This is, however, not to be taken as a retraction of what was said in that paper, but rather as furnishing ground for greater clarity where the need was even then apparent. The conclusion drawn from the study made with Vinke and published in 1934, was that spasm or contracture of the piriformis muscle may be a potent factor in the production of sciatic pain. The suggestion to cut the muscle was made by Joseph A. Freiberg, and it was felt that this might constitute a useful procedure and, at the same time, furnish corroboration of the theory which was being postulated. The conclusion

* Deceased.

appears to be justified. However, the procedure was not offered as routine and is not now so offered. It has become plain as the result of personal observation, as well as the recorded observations of others, that both success and failure have attended the employment of the different surgical attacks upon muscle and fascia which have been put forward, namely:

1. The stripping of the attachments of the glutei, proposed by Heyman.
2. Novocain or procaine injection at the site of tenderness,—the method of Steindler.
3. The incision of the fascia lata, as proposed by Ober.
4. The incision of the piriformis muscle.

In communicating the account of the anatomical studies concerning the relationship of the piriformis muscle and the sciatic trunk, in 1934, there was no element of self-deception. It was not assumed that anything was definitely proved concerning the pathological physiology of sciatic pain. Similarly, in the absence of a great volume of clinical material and, considering the difficulty associated with the personal and psychic factors which are involved, an extremely conservative attitude has been taken by the author and his associates as to the appraisal of the results obtained by the operative procedures. Much the greater number of cases of sciatic pain which have been observed in three hospitals and which are considered to be unassociated with organic intraspinal lesions, have responded to non-operative treatment, consisting chiefly of traction, followed by mechanical support and physical therapy. Twelve patients who have had section of the piriformis muscle have been satisfactorily followed. In nearly all of them, the relief of pain was immediate. In two instances some pain remained for several days. In two of the twelve, relief of pain was not secured; they are considered failures, and should not have been operated upon. Among the earliest cases there were three patients in whom absence or very great weakness of the Achilles reflex on the operated side was noted. The author would feel justified, today, in suspecting that these symptoms represented organic intraspinal lesions, possibly from intervertebral-disc damage. However, it is interesting to note that in two of these three patients, sciatic pain was definitely disposed of. The third case is recorded as a failure. In the first of these three patients, operated upon five years ago, the physician reports that the Achilles reflex is still absent, and that sciatic pain has not recurred, although two attacks of fairly severe low-back pain have been experienced. This patient is reported now as the subject of a definite proliferative polyarthritis. Both of these cases, however inconclusively, raise the question whether the sciatic pain may here be explained as the merely irritative effect produced by an organic lesion.

Cases in which there is definite evidence of lesions of intraspinal or other organic structures, and direct involvement of the radicles or trunk

of the sciatic nerve, may be eliminated from the discussion as they belong in a different and special category. The cases with which we must be here concerned are chiefly those of sciatic pain of long standing.

Much more experience is required to justify a pronouncement which may be trusted to have an abiding value. As has already been said, successful results have been observed by the author in a limited number of cases treated by the methods of Heyman, Ober, or Steindler. These methods have been employed when it was thought that they were indicated, but in numbers too small to be worthy of statistical report. Like the explanation offered for the results of the piriformis operation, however, their explanation is one of rationalization rather than of proof. It would appear that the establishment of indications for the various procedures must rest largely upon such explanation, or upon a basis which is personal and empirical. Once surgical intervention seems called for, however, it will have to be acknowledged that in other operations an attack is being made upon structures much less directly connected with the sciatic trunk than is the piriformis muscle. Here we are at least concerned with a structure which is always in direct contact with the sciatic nerve, even though not always to the same extent or in precisely the same way. Much more study and experience would appear to be essential before the establishment of precise indications for surgical intervention is accomplished either with regard to time or the choice of method. It must be granted that the indications will have to be set forth on a purely objective basis, and therefore, upon one which bears no prejudicial and personal connection with one's rôle in the development of a method. To this the author is definitely committed.

The proposal to cut the piriformis muscle for the relief of sciatic pain was originally put forth with the idea that this might be welcome as a symptomatic release, in certain cases which had failed to yield to non-operative methods. While the possibility of disease primarily situated in the muscle itself was granted, the operation was done in the absence of definite evidence of its existence. Muscle contracture of continuing character is most often secondary to a lesion situated primarily elsewhere. When it is primary in muscle or fascia, it is conceived to be the result of inflammatory disease,—myofascitis, or as the British say, fibrositis. In no instance in which microscopic study of excised piriformis tissue was made, was there a report of local disease. In the absence of this it is concluded that the rôle of the muscle in producing sciatic pain is secondary. The same thing will have to be said in the case of operation on other muscular or fascial tissue. Unless there is tangible evidence of disease in the tissue itself or in the dominant nerve control, a merely symptomatic release is unsatisfactory. The primary lesion will have to be recognized and subjected to suitable treatment. Such recognition often makes an operation of any kind unnecessary. Here, for the time being, at least, the case must rest.

THE ARTICULAR FACETS IN RELATION TO LOW-BACK PAIN AND SCIATIC RADIATION

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INTRODUCTION

Numerous authors in the past thirty years have emphasized the possible importance of the articulations of the vertebral articular processes in low-back pain and in sciatic radiation. The publications of von Lackum, Danforth and Wilson, Ayers, Putti, Williams, Ghormley, and others between 1925 and 1933 showed renewed interest in the articular facets as possible causative factors in the production of sciatic pain. Indeed, Ghormley in 1933 coined a very expressive phrase, "the facet syndrome", which promised to stimulate further investigation of the rôle of the facets.

The recognition of the clinical application of the findings of Schmorl and Andrae concerning the protrusion of the nucleus pulposus, by Stookey, Mixter, Barr, Love, and many others, has temporarily at least turned the attention away from the facets and the plausible theories of their part in the production of sciatica, to the intensely interesting problem of the moment,—the protruded disc.

Recently, Ayers (in 1935) and Putti (in 1937) have again reported clinically and anatomically, respectively, the lumbosacral joint and its facets as factors in low-back pain. To the unprejudiced observer, well acquainted with derangements of the low back, posterior protrusion of the nucleus pulposus as the causative agent of low-back pain and sciatic radiation will always be regarded as a definite factor which occurs in a minority of patients with the sciatic syndrome. In the author's series of studied cases previously reported less than 20 per cent. show any neurological evidence of direct nerve irritation. The excellent response to conservative treatment in the cases without neurological signs, verifies our contention, previously expressed, that 80 per cent. of the cases of low-back pain with sciatic radiation are on the basis of referred pain, and not direct nerve irritation.

It is the purpose of this paper to present a review of the possible rôle of the vertebral articular facets in the production of low-back pain and sciatic radiation.

ANATOMY

It is important to recognize that the articulations formed by the vertebral articular processes (the articular facets) are true joints provided with a complete capsule which is lined with a definite synovial tissue. Closely associated with the mesial aspect of the capsule are the ligamenta flava. Piersol states that the outer portions of the ligamenta flava are

FIG. 1-A

Third and fourth lumbar vertebrae articulated to show asymmetrical facets on the right side. There is marked osteophytic proliferation on the superior surface of the lamina of the fourth lumbar and on the inferior surface of the facet, resulting in contact of the cephalic portion of the superior facet with the inferior surface of the lamina of the third lumbar vertebra.

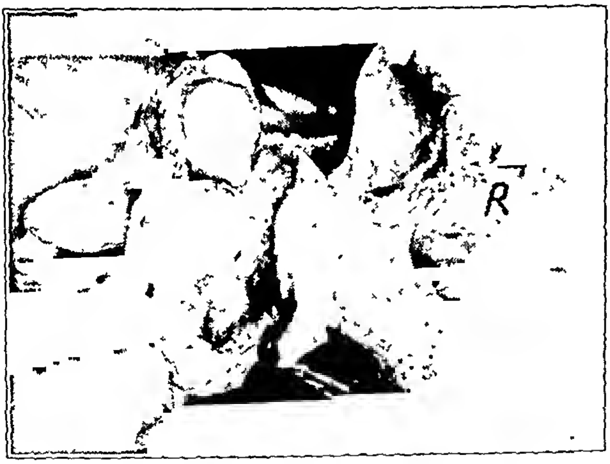

FIG. 1-B

Detailed view of the superior facets of the fourth lumbar vertebra, showing more clearly these changes and the notch on the superior surface which engaged the lamina of the third lumbar vertebra.

inseparably attached to the loose articular capsules, preventing, by their tension, the occurrence of folds. They encroach on the sides of the capsules toward the canal, and *take the place of muscle* in preventing the capsule from being nipped between the articular surfaces during movement. The ligamenta flava are also valuable, according to Cunningham, because they restore the articular surfaces to their normal position with regard to each other after movements of the spinal column.

In general, the lumbar superior articular processes are stout, oval, curved plates of bone, fused in front with the roots of the laminae, with their concave articular surfaces vertical and turned medially. The inferior articular processes lie on either side of the root of the spinous process supported on the inferior margin of the laminae. Their articular surfaces, oval in outline, convex from side to side, and plane from above downward, are turned laterally. The inferior articular surfaces are closer together than the superior, so that, when articulated, the superior articular processes embrace the inferior articular processes of the higher vertebra. The inferior articular processes of the fifth lumbar are farther apart than the other lumbar vertebrae and their articular surfaces are directed more backwards than inwards and display less concavity. The superior articular surface of the first sacral has a vertical articular surface, of circular or oval form, which is concave from side to

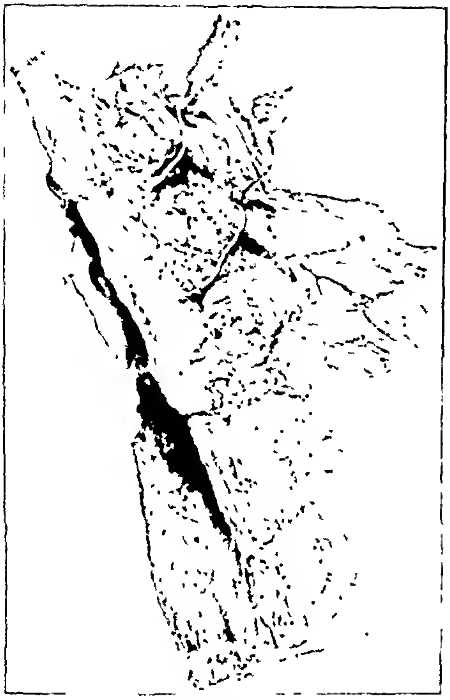

FIG. 2-A

Anatomical specimen demonstrating a dissection of the posterior primary division of the third and fourth lumbar nerves. The median branch can be traced in close proximity to the inferior surface of the articular facet, winding around it and even giving periosteal branches to it, but with no observable connection between the nerve and the capsule. The nerve terminates in the sacrospinalis muscle and is primarily a motor nerve. The lateral branch is shown to the right with a small piece of muscle attached.

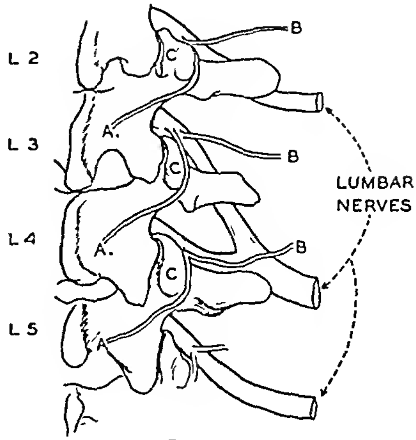

FIG. 2-B

Schematic drawing from the anatomical specimen.
A: Median branch of the posterior primary division.
B: Lateral branch.
C: Facet articulation.

side, with the general inclination backwards and a little medially.

Willis has pointed out that developmental variations of the articular processes in size, shape, and angle of projection, occur particularly in the lumbosacral region. He also states that poorly developed and asymmetrically formed articular processes strongly suggest mechanical instability and susceptibility to ligamentous injury.

Putti stressed the importance of asymmetrical development of the articular facets, regarding it as an anomaly of articular tropism.

Goldthwait recognized two well-known variations from the normal skeleton which are liable to produce backache,—(1) the tall slender visceroptotic type with long narrow flexible spine and flat type of lumbosacral facets, and (2) the short thick heavy type in whom the diarthrodial facets are large and crescentic and limit the motion of the vertebrae, particularly in flexion. Goldthwait pointed out that if the facets were asymmetrical, the movements were irregular.

Brailsford, in a review of 3000 roentgenographic studies of the lumbosacral spine, found that 57 per cent. of the lumbosacral facets pointed backward, 12 per cent. pointed inward, and 31 per cent. were mixed or asymmetrical.

More recently Putti, in a study of the anatomy of the vertebral apophyses, pointed out that there was a general shape of the articular por-

tion of the facets as described by anatomists, but that often the facets were flat and sometimes asymmetrical. He found that the inclination of the articular surfaces increased in the lumbar region from the first to the fifth with the minimal inclination usually 20 to 30 degrees in the upper lumbar area and 40 to 50 degrees in the fifth lumbar. Asymmetry with frontal facets on one side and sagittally placed facets on the opposite side occurred, particularly in the fifth lumbar, in six of seventy-five cases observed by Putti.

We have had the opportunity, through the kindness of Professor McCotter of the Department of Anatomy, and my associate Dr. Batts, to examine a large number of lumbosacral articulations. It has been expressed by Putti, and it is also our observation through roentgenograms, that there is a great frequency of facet abnormalities in the fourth lumbar. More frequently, distinct differences occur in the lumbosacral area and, phylogenetically, the frequency of abnormality should be greater in this region.

A careful measurement was made of 100 fifth lumbar inferior articular facets and first sacral superior articular facets. The variation in the sacral facets was reduplicated, within our ability to measure in degrees, exactly in the inferior fifth lumbar facets, so our findings are expressed only in the study of the superior articular facets of the sacrum.

FACET STUDIES

It is obvious that in general there is a normal for the inclination of the sacral facets, with an average angle of about 50 degrees from the sagittal plane. The average of inclination in this series agrees within a degree with Putti's findings. It will be seen by Table II that 79 per cent. of the cases did not vary 10 degrees from this inclination. Twenty-one per cent., however, showed as much as 11 to 30 degrees increase of inclination. One out of every five specimens showed an appreciable asymmetry.

FIG. 3

A fifth lumbar body demonstrating asymmetrical facets, osteophytic process at pedicle, and facet protruding into the spinal foramen just at the site where the fifth lumbar nerve winds around the body of the vertebra.

Facet Motion

It is stated in most anatomies that "flexion and extension are free in

TABLE I

ANGLES IN DEGREES OF SACRAL ARTICULAR FACETS WITH THE SAGITTAL PLANE IN ONE HUNDRED DRIED SPECIMENS OF SUPERIOR SACRAL FACETS

Angles	Average (*Degrees*)	Variation (*Degrees*)
Right	51.41	19– 87
Left	52 47	17– 90
Right and Left	103 88	55–177

the lumbar region, especially between the third, fourth and fifth vertebrae where the lumbar curve is the sharpest; lateral inclination is also very free between these same vertebrae. The shape and position of the articular processes of the lumbar vertebrae are such, that very little rotation occurs in this region." [8] Morris points out that there is always some space in which horizontal motion can occur around an axis down through the central part of the bodies and intervertebral discs, but it is very slight. Professor McCotter is convinced that this is an accepted, but somewhat

TABLE II

PERCENTAGE OF VARIATIONS OF NUMBERS OF DEGREES BETWEEN THE ANGLES MADE BY THE RIGHT AND LEFT SACRAL ARTICULAR FACETS WITH THE SAGITTAL PLANES

Variations (*Degrees*)	Cases (*Per Cent.*)	
0	9	79
1	9	
2	11	
3	6	
4	4	
5	8	
6	13	
7	5	
8	4	
9	9	
10	1	
11–15	15	21
16–20	2	
21–30	4	

erroneous impression. He feels that much more rotation occurs in the lumbar spine normally than has been thought possible. He bases this contention, first, on the shape of the facets, which are so constructed as to allow rotation, and, second, on the definite evidence in a number of skeletons of wearing of the articular processes and the bodies of the vertebrae, which could be explained in no other way than by rotation in the lumbar spine. (See Figures 1-A and 1-B.)

Von Lackum, in an anatomical study of thirty cadavera with eighteen grossly asymmetrical lumbosacral facets, states that when the articulations are asymmetrical they result in unequal rotation, a factor that also contributes to the weakness of the part. When there is associated with this condition a poor muscular or ligamentous development, or when there is a settling down of the superior articular facets onto the inferior facets from any cause, a very potent reason for disability or abnormality is established.

The Articular Portion of the Facets

Putti has made a comprehensive study of the size, shape, and inclination of the articular surfaces of the facets. There is as much variation in the true articular surface, as is found in the asymmetry of the entire facet. The area of the articular surface is usually 20 by 18 millimeters, but is commonly somewhat larger in the lumbosacral region. In normal conditions, the diameters vary from 8 to 10 millimeters in one direction, and from 9 to 11 in the other. Under this limit, Putti feels hypoplasia of the process exists. Not infrequently there is an asymmetrical development of the articular portion of the facets on the corresponding sides, with a difference in size as great as 6 to 8 millimeters in the transverse diameter.

The articular surfaces are covered with hyaline cartilage, usually of uniform thickness, but sometimes thinning toward the center. Putti also found evidence in the articulation of the facet of synovial villi which were extremely variable in shape, size, and appearance, frequently having two lobes, sometimes the size of the head of a large pin, sometimes leaf-shaped. They are rich in blood vessels.

The capsule of the articular facets is richly ennervated with sensory fibers, according to von Luschka. Most anatomists state that the primary posterior division of the spinal nerves supply the facet capsule, but that occasionally the recurrent nerve of the anterior primary division is the only sensory supply. At our request Professor McCotter and Dr. Strong dissected carefully the lower lumbar and lumbosacral nerves, and traced the medial branch of the posterior primary division of the third, fourth, and fifth lumbar nerves posteriorly. The individual nerves had a characteristic pathway, the medial branch curving in close continuity around the inferior margin of the facets, with some fibers extending into the periosteum of the facets, but continued as a motor nerve to supply the sacrospinalis group of muscles, without actual evidence of contact with the capsule of the facets. It is possible that the innervation of the capsule in this case came from the recurrent branch of the anterior primary division. Figures 2-A and 2-B demonstrate this dissection, showing the motor supply of the sacrospinalis from the individual lumbar nerves. The lateral branches were also dissected and also proved to be motor nerves.

The sensory nerve supply of the capsule of the facets is sufficiently well determined, to support the conception that irritation of the capsule of the lumbar articular facets could well produce pain stimuli which, through

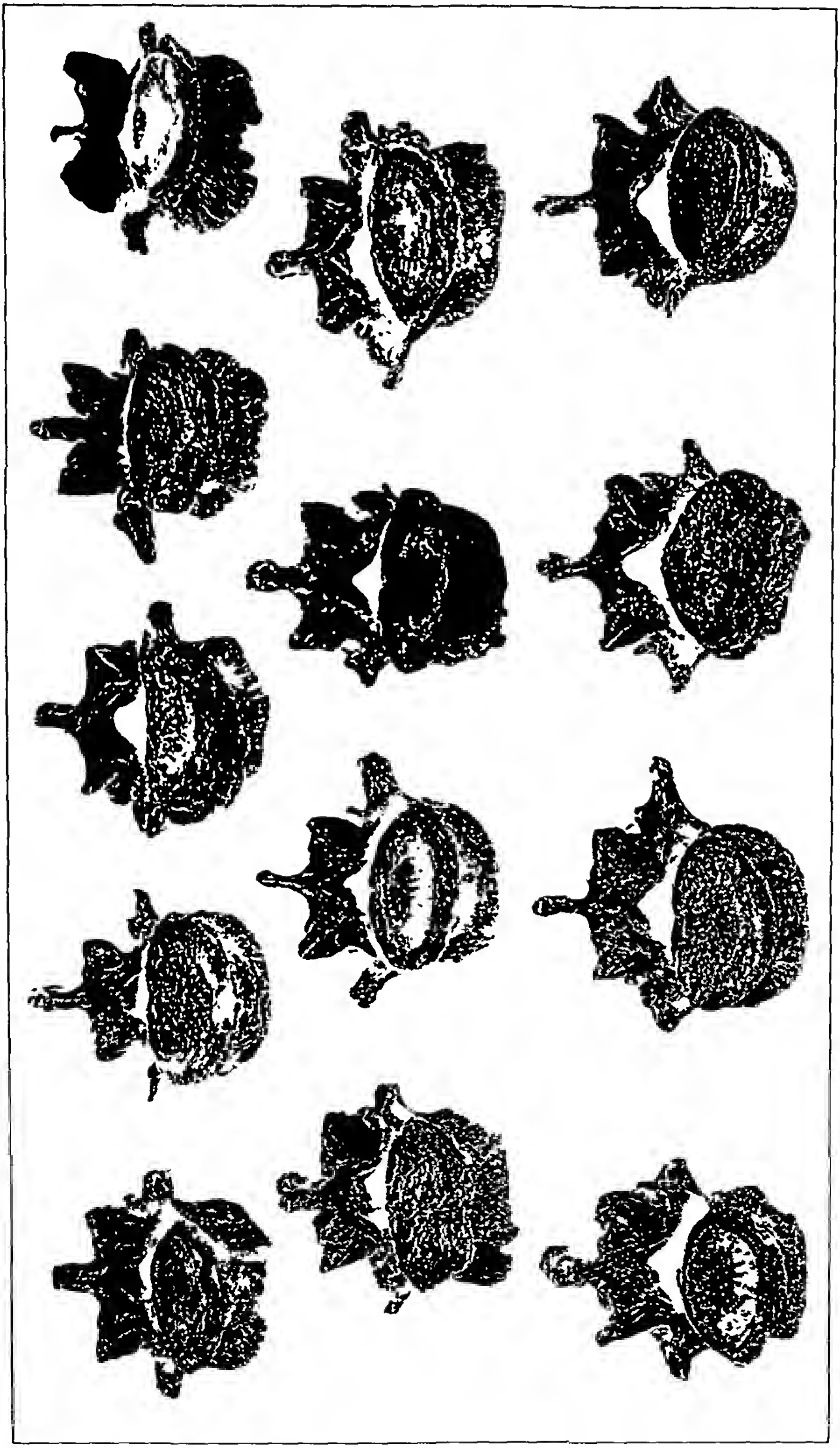

FIG. 4

Thirteen dried specimens of the fifth lumbar vertebra are arranged to show the inferior articular facets. The variations in size, shape, and inclination of this unselected group are characteristic. Osteophytic proliferation about the vertebral border is demonstrated in a number.

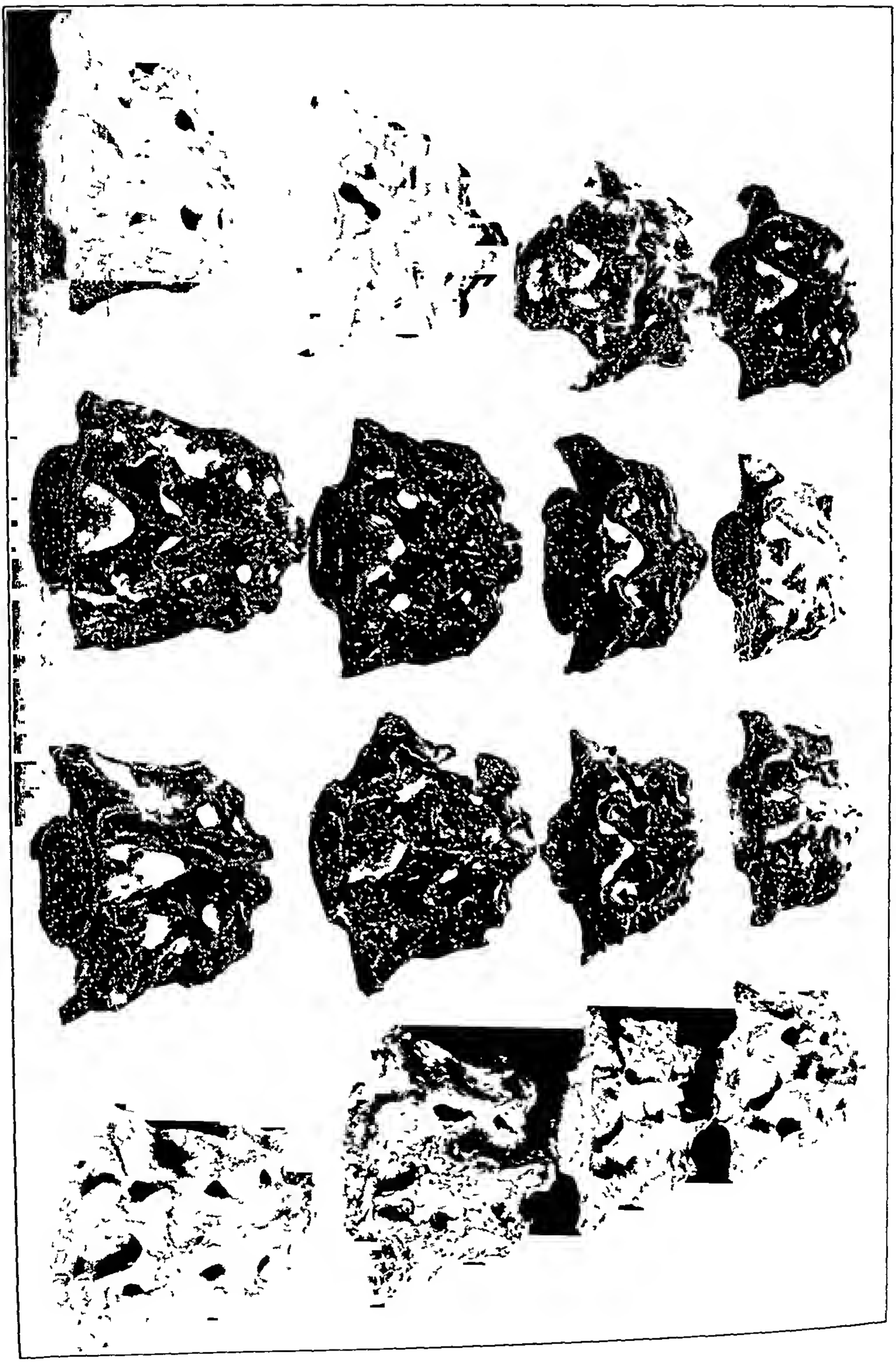

Fig. 5
Sixteen dried sacra illustrating the superior articular facets.

the primary posterior division, could return to the central nervous system and produce referred pain through the dermatomes of the involved nerves, which correspond exactly with the pathway of sciatic radiation,—namely, the fourth and fifth nerves. Thus sciatic symptoms on a referred mechanism, but along the same pathway as direct nerve irritation, can conceivably be produced. The author[4] has previously presented his theory of postaxial radiation as referred pain, not necessarily produced by direct nerve irritation.

Fig. 6

Three specimens of the sacrum demonstrating the wide variation of inclination of the facets.

The anatomical relationship of the fifth lumbar nerve to the superior articular facet of the sacrum as the nerve passes through the intervertebral foramen has been stressed by various authors. The vulnerability of the intervertebral foramen by its alteration in size and shape through the mobility of the intervertebral disc and the articular facets has been excellently expressed by Danforth and Wilson. The increased encroachment of the intervertebral foramen in pathological conditions—such as narrowing of the lumbosacral disc, arthritis of the lumbar facets, and asymmetry of the facets with unilateral abnormal motion—has been described in most convincing manner by Ayers[3], Williams, and Ghormley. Anatomical support for the possible injury to the fifth lumbar nerve root in the intervertebral foramen seems as definite as the evidence of posterior protrusion of the nucleus pulposus and its relationship to the fifth lumbar nerve intraspinally, but pathological evidence is lacking to substantiate the anatomical.

The importance of the frequent clinical finding of narrowing or reduction of the fifth lumbar intervertebral disc, producing subluxation of the facets, in the necessary adaptation of the articular facets to this mechanical alteration of their function, has been well demonstrated.[10, 35] To allow for the approximation of the fifth lumbar body to the sacrum, the superior facets of the sacral vertebra must encroach toward the inferior vertebral notch of the fifth lumbar, even, in some instances, to the extent that they are stopped by contact with the lamina or the sacrum.

PATHOLOGICAL CHANGES

The anatomical evidence of the possibility of participation of the facets in the production of low-back pain and sciatic radiation has been

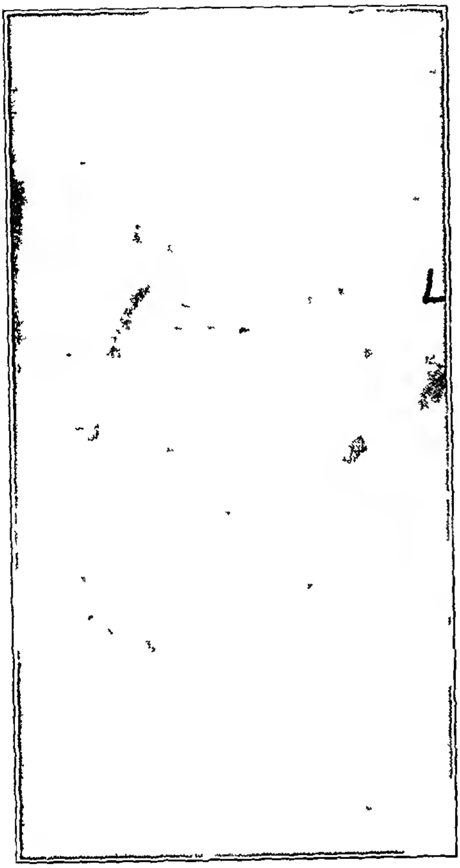

FIG. 7-A

Roentgenogram showing asymmetrical facet between the third and fourth lumbar vertebrae. On the left side the facet is much higher and smaller

FIG. 7-B

Oblique view shows loss of clear view of facets of the fourth and fifth lumbar vertebrae on the left side.

greatly enhanced by further anatomical evidence of pathological changes and by roentgenographic and clinical findings which are sufficiently sound to warrant greater interest and investigation in the facet syndrome.

Sicard, quoted by Putti, stated that the intervertebral foramen is the cross road of neuralgia, and any condition which modifies the contents or the container (the intervertebral foramen, or the nerve or other structures within the canal) at once induces a painful reaction which is referred distally to the sciatic nerve. Putti for years maintained that sciatica is a neuralgia caused by a pathological condition of the intervertebral foramina and especially of the intervertebral articulations, the articular facets. It was his opinion that idiopathic sciatica is essentially the result of vertebral arthritis involving chiefly the articular facets.

Putti and Logròscino, in a recent anatomical study of seventy-five preparations of the lumbar and sacral regions, found that apophyseal arthritis is seen very frequently. These authors excepted individuals under thirty years of age who manifested no evidence of arthritis; they excluded six more, four of them in their early thirties, who had only minimal evidence of arthritis. In the remaining specimens, arthritic

FIG. 7-C
On right side the facets are clearly visible all the way to the first sacral vertebra.

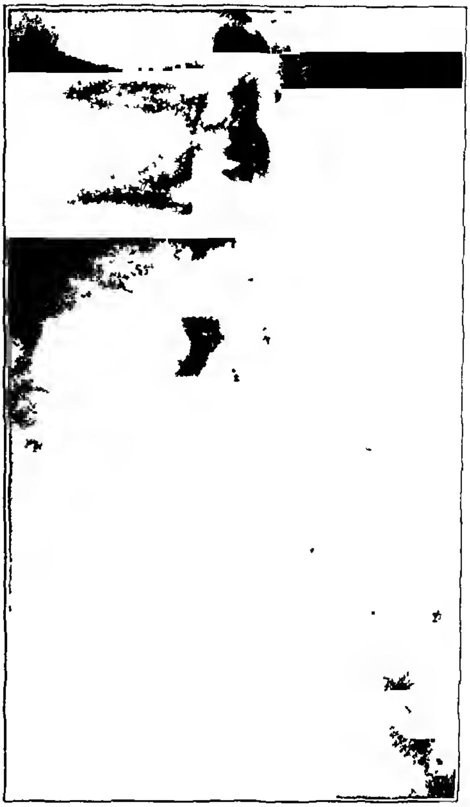

FIG. 7-D
Lateral view shows normal appearance with normal disc spacings.

lesions in various phases of development were found constantly. Arthritis of the facets is rare under thirty years of age, but is progressively more frequent and severe with age. Intervertebral arthritis is more common between the third and fourth, and fourth and fifth lumbar vertebrae, and a little less common, surprisingly enough, in the lumbosacral region itself. Arthritis of the facets is more commonly associated with the asymmetrical facets. Lesions of the articular capsules were found in fifty-seven of the seventy-five cases, appearing usually in the upper and mesial part of the capsule with oedema, granular ossification, calcification, and adhesions between the capsule and the meningeal covering of the nerve root adjacent to it.

Changes in the synovial membrane were found analogous to changes in other joints in a degenerative process. Hypertrophic villi, of three to four times normal size, with chondrification and ossification occasionally in the villi; detached chondral bodies; and ulcerative areas, with complete loss of cartilage, were observed. Degenerative changes of the articular surfaces with thinning and fibrillation of the cartilage, and osteophytic marginal proliferation were frequently seen.

FIG. 8-A

Frontal view showing a saddle-shaped facet between the fourth and fifth lumbar vertebrae on the left side, and frontal type facet on the right side.

FIG. 8-B

Left oblique view further demonstrates the saddle-shaped facet

Putti and Logròscino stated that they were particularly interested in the changes noted anatomically, which were not observable in roentgenograms. They presented, from their anatomical knowledge, certain signs noted in the roentgenogram which will enable the observer to recognize this form of vertebral arthritis roentgenographically, earlier than was previously possible.

Anatomical evidence is ample to demonstrate that the facets in the lumbosacral-joint area may and do suffer from all of the ills that are inherent to joint structures. Putti demonstrated changes in the synovial membrane, and free bodies in the joint that might conceivably produce symptoms akin to those of knee-joint derangement. The frequency of asymmetry of articulations required to function simultaneously must be a factor in repeated joint trauma. A mechanically unsound joint in the hip or elsewhere shows reaction to irritation as the patient ages, and so must the asymmetrical and mechanically poor facets. From Putti's studies he concluded that arthritis of the articular facets is the rule in practically all patients over forty years of age.

FIG. 8-C

Right oblique view shows normal facets.

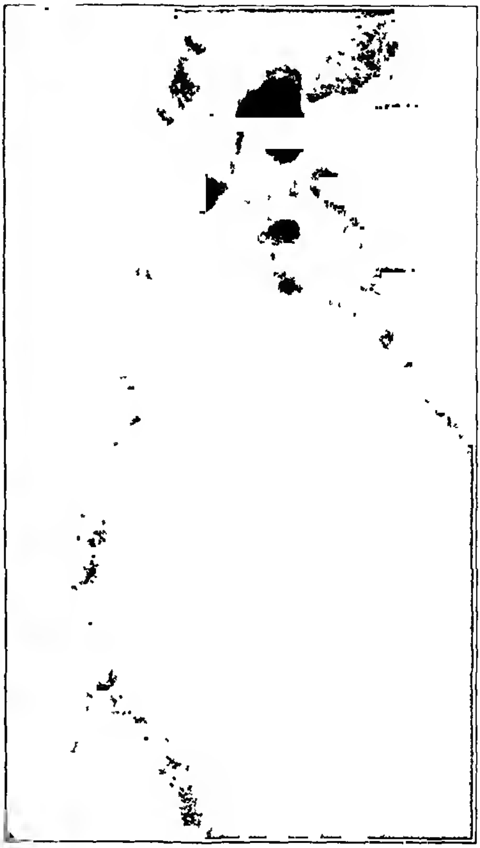

FIG. 8-D

Lateral view shows normal disc spacing.

ACUTE TRAUMA TO THE FACETS

It seems necessary to discuss briefly the characteristic roentgenogram of fissure formation—usually of an inferior articular facet—found in a patient with back symptoms or accidentally in roentgenograms. This lesion has naturally led to the question of congenital or traumatic etiology. It is probable that the majority are the result of anomalous development. Fracture may occur, but usually is found only with evidence of fractures elsewhere in the spine. The analogy of this fissured process to the os trigonum and os naviculare is so striking that the author concludes that the etiology must be similar.

To evaluate properly the part the facets play in the production of low-back pain, postmortem studies of the lumbar and lumbosacral area of the spine are essential. Such studies may eventually be obtained in the larger medical centers, but are not yet available. Until such objective proof is obtained, we must rely on clinical and roentgenographic evidence and the response to treatment, and, therefore, the facet syndrome will remain a theory and not a fact.

The author is constantly confronted with problems of low-back pain,

often without sciatica, but with a history of sudden onset of pain, and sciatic scoliosis associated with marked muscle spasms, with no neurological findings, and frequently, no sciatic radiation. Many of these cases present changes which fit in so well with the anatomical factors mentioned in this paper, that it is most probable their symptomatology is based on the facet syndrome. A brief history of two cases is illustrative of this point.

CASE 1. A neurosurgeon, aged forty, had a second attack of acute, incapacitating, low-back pain, with a marked list. The leg signs were negative except an Ober's sign on the right side which disappeared as improvement set in. The neurological examination was entirely negative.

Roentgenograms showed a normal lumbosacral disc. The only abnormalities noted were: (1) The frontal view showed asymmetry between the third and fourth lumbar articulation with malformation of the left facet, and spina bifida occulta of the first and second sacral vertebrae. (2) The lateral oblique views denoted an obliteration of the facets between the fourth and fifth lumbar, and the fifth lumbar and first sacral vertebrae, which very probably demonstrated only asymmetry of the facets.

CASE 2. An electric welder, aged thirty-four, complained of chronic low-back pain since a fall of twenty-four feet, six and one-half years before, which injured both ankles. Lumbosacral pain was worse while lying down, relieved by motion, and aggravated at times while at heavy work. The clinical examination was essentially negative except for lumbosacral tenderness.

Roentgenogram of the frontal view showed a left asymmetrical facet between the fourth and fifth lumbar vertebrae and failure of complete closure of the lamina of the fifth. The oblique view showed the saddle-shaped facet on the left side.

The two cases are indicative of a great number of similar cases, where symptomatology may well be based on the facet syndrome. Their response to conservative treatment is excellent, but recurrence of difficulty is very possible. Fusion of the affected area usually results in complete relief.

CONCLUSIONS

1. The anatomical possibilities for the articular facets to play a more or less active part in the production of low-back pain with or without sciatic radiation are obvious, but pathological evidence is not yet sufficient to make this conclusion a fact.

2. Clinical evidence, in case of low-back pain with or without sciatic radiation, of pathology in or affecting the articular facets, requires serious consideration of the articulation in all cases of this syndrome.

3. The frequency of arthritis in the facets as age progresses, and the frequency of low-back disturbances in similar age periods, are coincidental facts of very probable significance.

4. Sciatica is a symptom complex, in which the syndrome is the only constant factor; the causative factors are variable and may be single or multiple, but the rôle of the facets should be considered in every case.

5. Rotation of the lumbar, and particularly of the lumbosacral articulation, occurs to a greater extent than anatomists have recognized. In this region it takes place chiefly in the facets, instead of in the intervertebral discs as it does in rotation in the thoracic region.

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CONGENITAL PSEUDARTHROSIS

Treatment by Dual Bone Grafts *

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The purpose of this paper is to discuss congenital pseudarthrosis and to suggest a method of treatment by homogeneous dual bone grafts.

Congenital pseudarthrosis occurs in the lower half of the leg. The typical findings of the condition in this location form a specific surgical entity. Rarely, congenital bone defects may be found in other locations, but the condition discussed in this paper will be limited to those occurring in the lower half of the tibia or in the tibia and fibula.

Several theories have been advanced regarding the etiology of congenital pseudarthrosis. The most probable are: congenital defect in the tibia, resulting from a deficiency in the germ cells; congenital absence of the nutrient artery of the tibia; and fracture through a bone cyst, followed by non-union. Either of the first two may well account for a congenital defect in the tibia. Pseudarthroses which develop after birth are probably due to bone cysts. These cysts have been described by Wade, Inglis, Compere, Scott, and others. Scott reported a case illustrated by serial roentgenograms, showing the tibia before the cyst was demonstrable, followed by the development of the cyst, fracture of the tibia, and formation of the pseudarthrosis. The cyst was first noted in the cortex of the anterior border of the tibia. As a cyst develops, the tibia gradually bends forward, producing the anterior bowing usually seen in this condition. Fracture occurs following slight trauma or spontaneously.

The formation of cysts, followed by fracture, can be conclusively demonstrated in some cases, and is a plausible theory in others. The theory of congenital absence of a segment of the tibia seems to fit the facts more closely in patients without evidence of cyst formation in the roent-

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, New Orleans, Louisiana, on January 14, 1941.

genogram, and with long tapering ends on both the proximal and distal fragments of the tibia.

Pathologically and roentgenographically the cysts seen in the tibia resemble those evident in localized osteitis fibrosa, but the cysts in the two conditions behave differently following fracture. There is practically no effort on the part of the body toward spontaneous healing of the fracture in the congenital cases, whereas healing with callus formation is the rule following fractures through cysts in patients with osteitis fibrosa. Osteitis fibrosa (bone cysts) have a predilection for the upper third of the femur, humerus, or tibia, while the cysts predisposing to pseudarthrosis are seen in the lower half of the tibia.

Congenital pseudarthrosis appears to be a purely local condition. In reported studies, blood calcium and blood phosphorus have been within normal limits. There is no relation between this condition and the Wassermann reaction. None of the patients in our series had a positive Wassermann. Colonna reported a patient with congenital pseudarthrosis, who had three operations before coming to him. Three additional bone grafts were done; all were failures and the leg was eventually amputated. During this period of treatment, the child sustained two traumatic fractures in the unaffected leg; both of these united normally. The supramalleolar osteotomies for valgus of the ankles, done in Case 1 of this series, united in a normal period of time.

Barber has called attention to a relation existing between congenital bow legs, pseudarthrosis, and von Recklinghausen's neurofibromatosis. Moore has also discussed the relationship of neurofibromatosis to orthopaedic conditions. Two of the four patients reported in this paper exhibited areas of pigmentation similar to the "*café au lait*" spots reported by these authors (Cases 1 and 2).

Camurati classifies pseudarthrosis of the tibia in three clinical types: latent, fixed, and mobile. In the first, there is no break in continuity of the tibia. The leg is usually curved anteriorly. The diaphysis is atrophied and shortened, and the medullary canal is partially or entirely obliterated. In the fixed type there is a dense connective tissue, bridging the pseudarthrosis of the tibia, and the fibula is intact. In the mobile form, an osseous defect is present in both the tibia and fibula. The anterior curvature of the tibia usually forms an acute angle. The ends of the fragments may be hook-shaped or pointed.

From this classification it is difficult to differentiate the "latent" group from congenital bowing of the tibia. The prevalence of pseudarthrosis following osteotomy of congenital bowing of the tibia and the extreme difficulty of securing union following such a pseudarthrosis suggest that the etiology in congenital pseudarthrosis and congenital bowing of the tibia may be related.

Practically, the patients can be divided into two groups,—those born with a defect in the tibia and those who develop a pseudarthrosis after birth. In the latter, the fracture is usually noted some time during the

first two years of life, and occurs secondary to a bone cyst, or is due to a fracture in the latent type.

Camurati, in 1930, reported twenty-seven cases and collected 118 from the literature. Of the 145 cases, 57.6 per cent. of the patients were males; 95.5 per cent. of the cases were unilateral. Ninety-seven of the patients had been treated surgically; of these, thirty, or 31 per cent., were cured; and twenty-one of the thirty cures followed bone grafts.

In the English literature, Henderson, Wade, Colonna, Compere, Hallock, and McFarland have reported a total of twenty-six patients treated surgically. Of these, thirteen, or 50 per cent., obtained union. A total of seventy-four operations were performed on the twenty-six patients,—an average of two and eight-tenths operations per patient. This number includes the operations performed on the patients before they were referred to the surgeons reporting the cases. The percentage of unions reported in the literature is probably higher than that usually obtained, as one rarely takes the trouble to report a series of failures. From these data one may conclude that there is no other condition in which bony union is so difficult to obtain as in congenital pseudarthrosis; however, these data also show that union is obtainable.

Success is primarily dependent upon the age of the patient and the efficiency of the operative procedure. It is the consensus that the older the patient, the better the chance of securing union. Camurati states that surgery should not be attempted under the age of six years. Henderson advises one well-planned operation in childhood and, if this fails, the postponement of further surgery until puberty. From the reported cases, it is evident that union is more easily obtainable in the older patients. If union can be obtained in young children, the end results should be much better, as the deformity and shortening of the leg associated with congenital pseudarthrosis increase as the child grows. When union is obtained in a young child, function and weight-bearing during the growth period predispose to a more normal development of the bone and leg. This is well illustrated in Case 1, reported in this paper.

Surgery offers the only practical method of obtaining union. If one wishes to postpone surgery because of the age of the patient, the lower extremity should be fitted with a leather lacer brace to support the leg and to prevent increase in the deformity. The age at which operation should be done is difficult to determine. The ages of the patients reported in this paper at the time of bone grafting were two and one-fourth years, four and one-half years, five years, and seven years. Since failure is common in young children, it is probably wise to postpone surgery until the child is five or six years of age. If the surgeon has the cooperation of the parents, a proper brace worn until this age will prevent gross deformity.

Many types of operations have been recommended. Incision through or "osteotomy" of the pseudarthrosis, followed by manipulation and immobilization in a cast, may assist in the correction of deformity, but is of no value in securing bony union.

Excision of the pseudarthrosis, exposing normal bone on each fragment, followed by apposition of the fragments with sutures and external immobilization, has resulted in too small a percentage of unions to warrant this procedure. It also necessitates wide resection of bone; this increases the shortening which is usually already present.

The percentage of unions following the use of osteoperiosteal grafts has been too small to recommend their use.

Hallock has used multiple bone chips to fill a gutter extending across the pseudarthrosis and into normal bone in each fragment. His results have been good. The small multiple grafts furnish excellent osteogenesis, but internal fixation is not obtained.

McFarland has described an ingenious "by-pass" bone graft. He reports two cases with union in each case. In this procedure, no attempt is made to correct the deformity. The graft is completely surrounded by soft tissue, which may be a theoretical disadvantage.

The massive onlay graft has been the operation of choice in this country and a fair percentage of success has followed its use.

Experience has demonstrated that the best end results in the treatment of non-unions following traumatic fractures have followed the use of the massive onlay graft, as described by Henderson or Campbell. Two principles are employed in each of these procedures. Secure internal fixation is obtained by means of a cortical tibial graft. Osteogenesis is promoted by packing cancellous bone about the fracture site.

Union in this condition is much more difficult to secure than in non-union following traumatic fractures. Faced with this fact, the surgeon should use more effective bone grafts in the treatment of congenital pseudarthrosis than in patients with ordinary non-unions. In an effort to do this, the technique of the dual graft as described was devised. The case reports illustrate how the dual graft was developed.

In Case 1, an onlay bone graft was employed. The graft was removed from the mother's tibia. Due to the small size of the child's bones, silver-wire loops were used to secure the graft, in place of autogenous bone pegs. This procedure was used four times in three patients. In one (Case 1) a union was obtained; the other three operations resulted in absorption of the graft and non-union. Thus, this procedure was successful in one-third of the patients and one-fourth of the operations. One of the other two patients is now an adult with non-union; the other had an amputation following the failure of the second graft.

With the development of vitallium screws, it was felt that they would secure better fixation of the graft than the wire sutures had. In Case 2, a massive tibial graft removed from the mother was employed and vitallium screws were used for fixation. Cancellous bone was packed about the fracture site. In this child, union was obtained but, in retrospect, there are two points of criticism. First, in congenital pseudarthrosis the bone may be too soft to enable the threads in the vitallium screws to secure a firm grasp. Second, although a large amount of cancellous bone

was packed about the fracture site, this bone was compressed by the organizing and contracting scar tissue which forms postoperatively about the fracture site. This results in a hemi-hour-glass constriction at the site of union and a diminution in the size of the tibia at this point. This constriction predisposes to refracture and hinders the establishment of a marrow cavity through the former site of pseudarthrosis. This hemi-hour-glass type of union also occurs in cases where a defect in bone is bridged with an onlay graft and the defect is filled with cancellous bone. These factors are especially marked where the bone fragments are pointed at the ends, as in Case 3. To overcome these objections it was decided to use the dual bone graft. The advantages of this method are:

1. Better mechanical fixation is obtained.
2. The tibial grafts are revascularized slowly, and provide rigid internal fixation over a long period of time.
3. The cancellous bone about the fracture is revascularized quickly and produces a strong osteogenic element.
4. With a single graft, the screws may fail to hold in osteoporotic bone. With the dual graft, a clamp is formed which compresses the tibial fragments between the two grafts.
5. The grafts form a trough to hold the cancellous bone which is packed around the fracture.
6. The grafts prevent compression of the cancellous bone by contracting fibrous tissue during the healing process. Hemi-hour-glass constriction of the bone at the fracture site is minimized.
7. The diameter of the grafted bone is increased.
8. Partial absorption of one graft does not necessarily result in refracture and failure, as the second graft maintains internal fixation.

TECHNIQUE OF THE OPERATION

A full-thickness tibial graft of suitable size (usually about nine inches long and three-quarters of an inch wide) is removed from the tibia of the mother or father. The endosteal bone is then cut with a motor saw from the cortical portion of the graft. Additional cancellous bone is removed from the upper end of the tibia with a curette. The cortical portion of the graft is divided at its center. This provides two cortical grafts about four and one-half inches long and an ample supply of cancellous bone.

The pseudarthrosis is then exposed through a long anterior incision. The connective tissue forming the pseudarthrosis is excised. The eburnated bone which covers the ends of the fragments is removed. Care is taken to conserve all the leg length possible. The medullary canal of each fragment is opened with a drill. The deformity is then corrected and, if necessary, the tendo achillis is lengthened through a second incision. If an associated defect in the fibula is not present, it may be necessary to osteotomize this bone.

A bed is prepared for the grafts on the medial and lateral surfaces of the tibia. Just enough bone is shaved from the sides of the tibia to insure

denuded areas for the grafts and a slightly flattened surface to receive them. In the expanded areas in the tibia at a distance from the pseudarthrosis, it is necessary to remove more bone to receive the graft than in the region of the pseudarthrosis. Considerable space may remain between the grafts at the fracture site. This is especially true if the ends of the fragments are pointed. This is not a disadvantage as the space is filled with cancellous bone. The narrow portion of the tibia is thus increased in size.

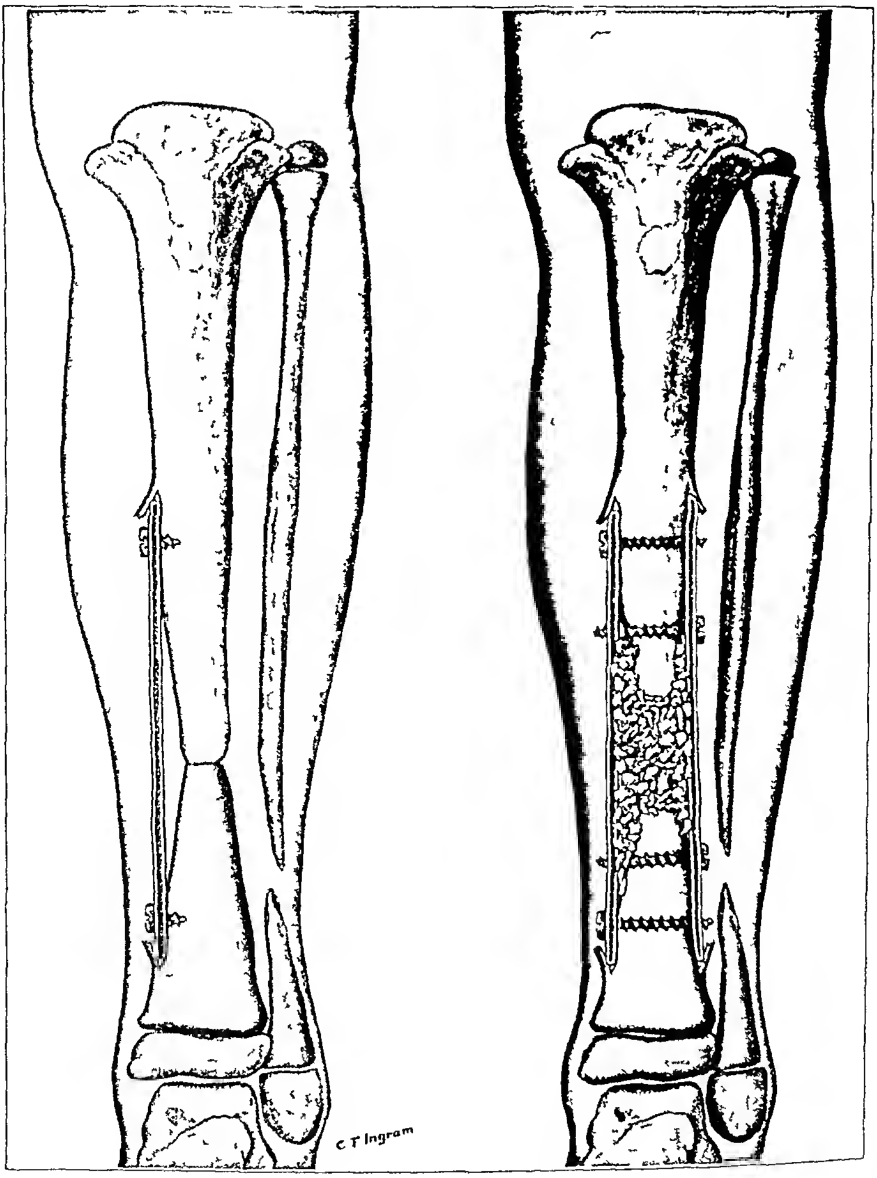

FIG 1-A FIG 1-B

Fig 1-A: The first graft has been applied and is held in position by two temporary vitallium screws

Fig. 1-B: Both grafts are in position and held by means of vitallium screws which pass through both grafts and the intervening bone The temporary screws have been replaced by the permanent screws

The grafts should extend as far down the tibia as possible without causing damage to the lower tibial epiphysis. The graft should extend for an equal distance or more above the fracture site. The longer the graft the better, and, in small children, it may extend to the upper tibial metaphysis.

One graft is placed on the inner or outer surface of the tibia and held by two short temporary vitallium screws. The second graft is then placed on the opposite side of the tibia and two long vitallium screws passed through the graft, the grafted bone, and the first graft. The short screws are then removed one at a time and replaced by long screws which pass through both grafts and the intervening bone (Figs. 1-A and 1-B).

The screws should not be placed too close to the fracture site. This error was made in the upper screw in the lower fragment of Case 3. As in all bone-grafting procedures, the drills should be of the proper size for the screws. The screws must be of the proper length to reach through the second graft. Screws of smaller diameter would be an advantage for use in children. As non-electrolytic machinable metals are developed, such screws should be available.

The trough, formed by the two grafts and the space about the pseudarthrosis, is then packed with cancellous bone. The entire space, both posterior and anterior to the pseudarthrosis, should be filled. This is an important step in the operation, as cancellous bone is a powerful osteogenetic factor.

The skin and subcutaneous tissue are then closed with interrupted silk sutures. No effort is made to close the deep fascia, as there is not sufficient soft tissue available after the application of the dual graft. The leg is immobilized in a cast from groin to toes.

Immobilization in casts is continued until union is demonstrable in the roentgenogram. A leather lacer brace is then fitted. These braces are made from a plaster mold of the leg and have no joint at the knee or ankle. Weight-bearing is permitted in the brace. Use of the brace is continued until a new marrow cavity has formed, connecting the proximal and distal fragments through the former area of pseudarthrosis, and until the size and density of the tibia approach the normal. This period of immobilization may be several years. The leg may be removed from the brace for bathing and to permit motion in the knee and ankle. Weight-bearing without the brace should not be permitted sooner than indicated above, as union following refracture may be as difficult to obtain as in untreated cases.

Valgus deformity of the ankle is usually seen in cases presenting a congenital defect in the fibula. This deformity increases with growth. Care should be taken to correct as much of the valgus as possible at the original operation. Bilateral supramalleolar osteotomies for correction of valgus deformity of the ankles were done in Case 1, as stated in the case report. A similar operation will be required in Case 3 at a later date.

Objections may be raised to the use of homogeneous grafts. Autog-

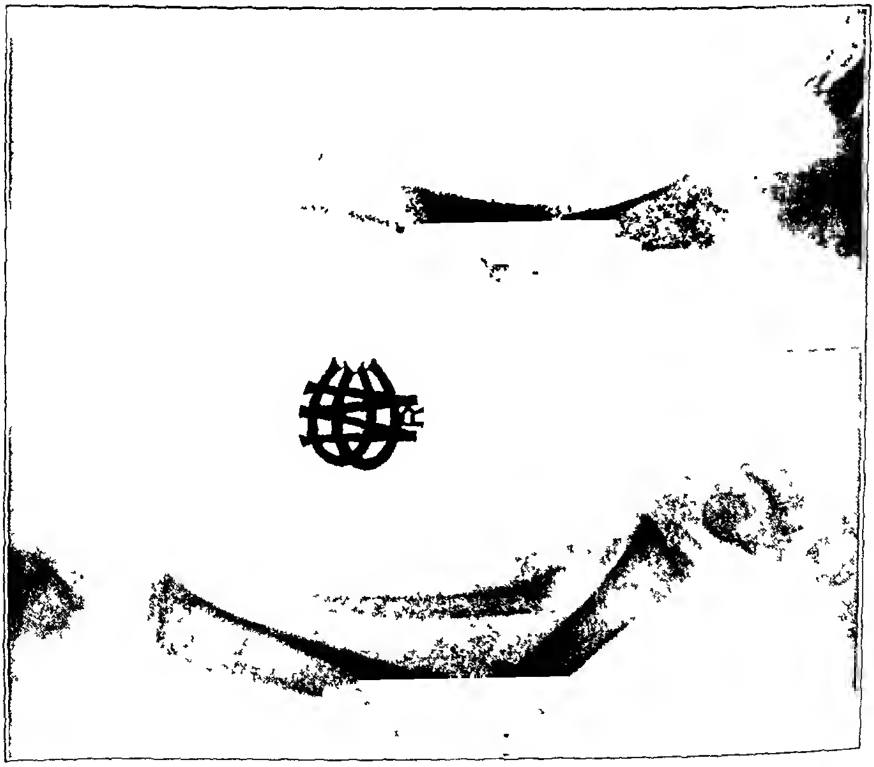

FIG. 2-A

Case 1. Preoperative roentgenograms, showing congenital pseudarthrosis of the right tibia with an associated defect in the fibula.

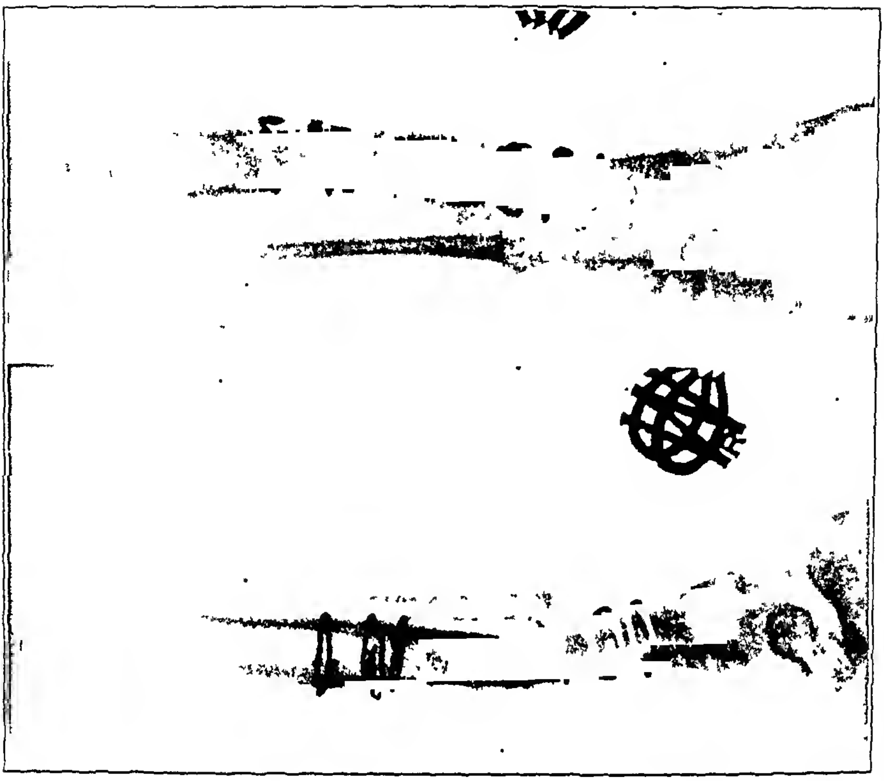

FIG. 2-B

Case 1. Union seven months after onlay bone graft. Silver wire was used for fixation of the graft. Bony union is present. A new medullary canal has not been established across the fracture site.

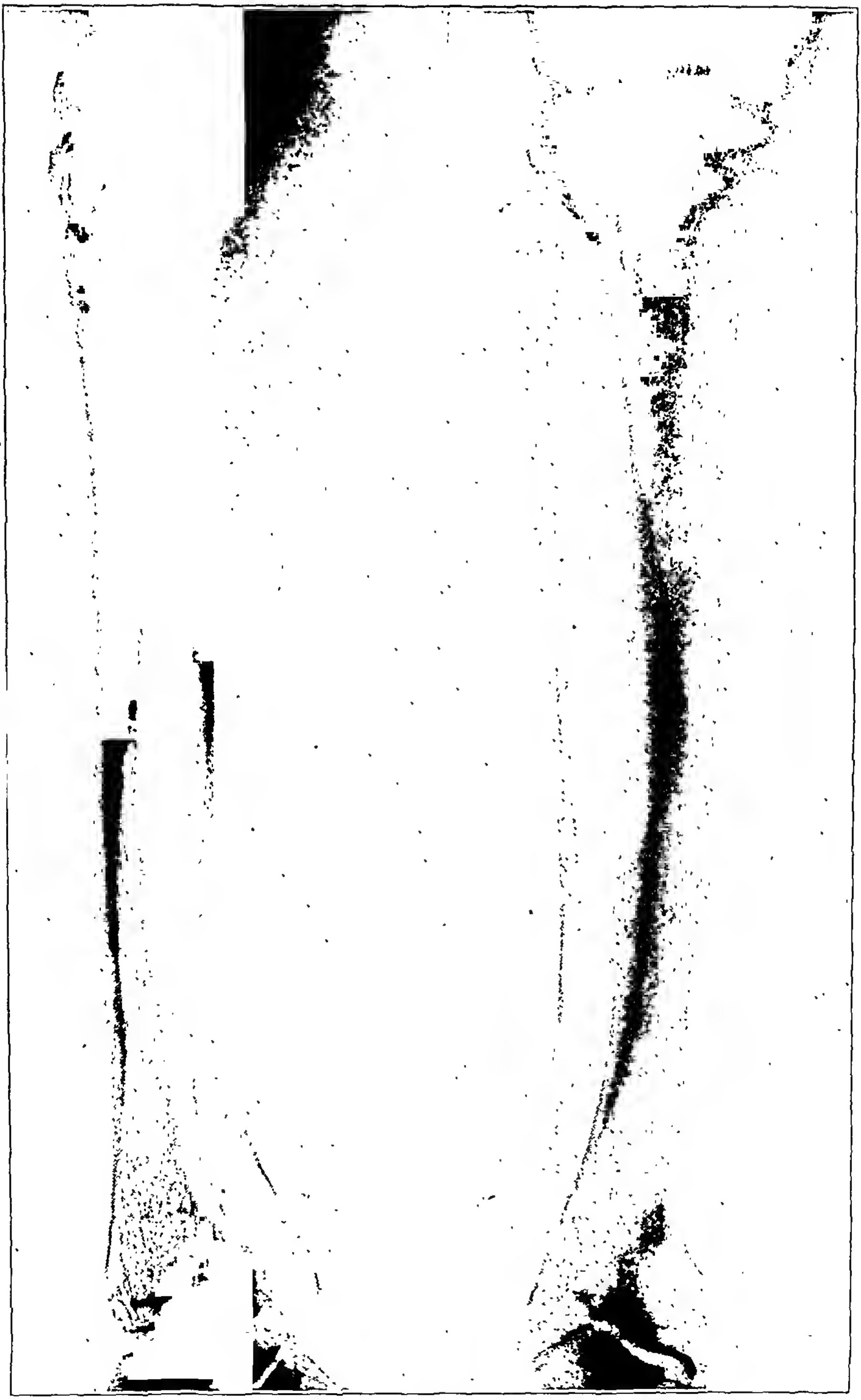

Fig. 2-C

Case 1. Roentgenograms taken fifteen years postoperatively. The shaft of the tibia is of normal size and density. The defect in the fibula is still present.

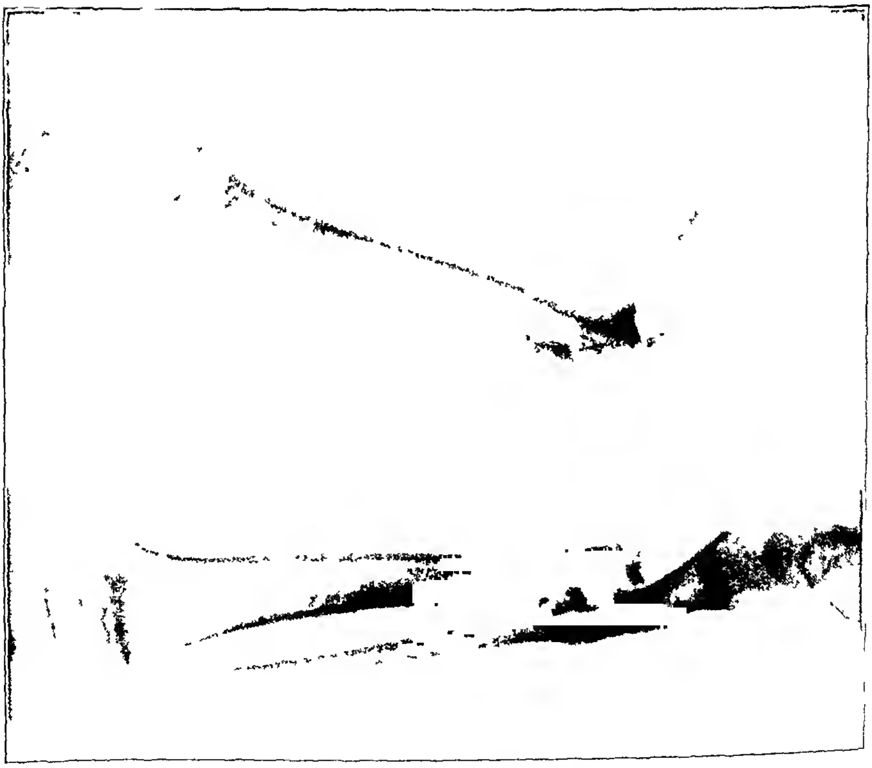

FIG. 3-A

Case 2. Preoperative roentgenograms showing congenital pseudarthrosis of the right tibia with associated defect in the fibula.

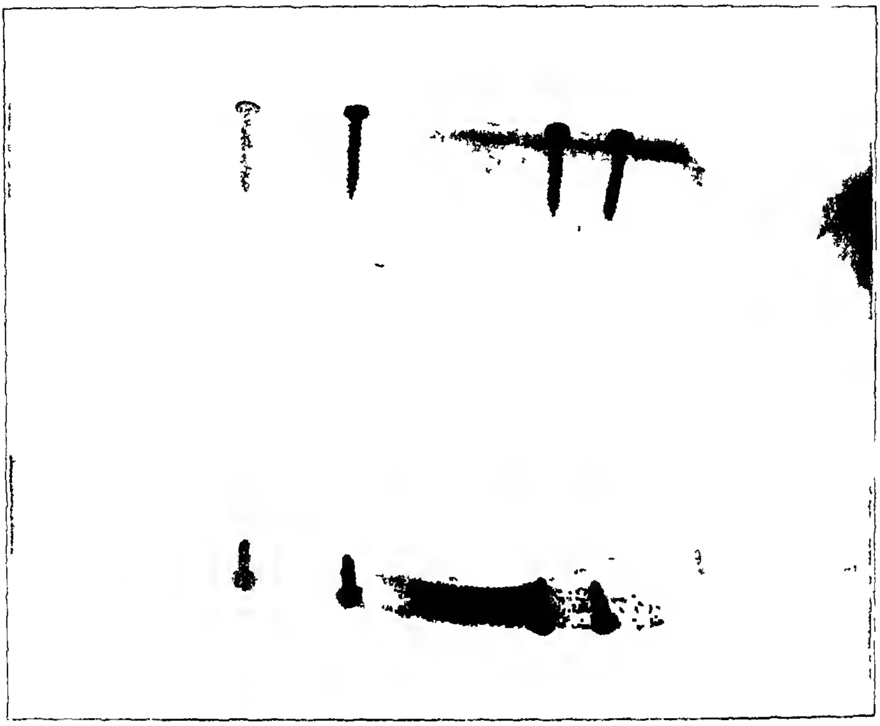

FIG. 3-B

Case 2. Roentgenograms taken four months postoperatively show solid bony union of the graft to the proximal and distal fragments, with beginning union at the fracture site.

enous grafts are preferred, but in children it is difficult to secure sufficient bone for a good onlay graft, and impossible to obtain enough for a dual graft. Practically, the homogeneous grafts have worked out nicely in the cases reported. The blood groupings of the bone donors and the patients are recorded for interest. It probably makes little difference whether the patient and the bone donor are of the same blood group, as bone is transferred, not blood. Alan De Forest Smith reported successful homogeneous grafts from bone donors in whom the blood grouping was not the same as that of the recipient, as well as in instances where the blood was compatible. Whether or not bone types exist may be determined in the future.

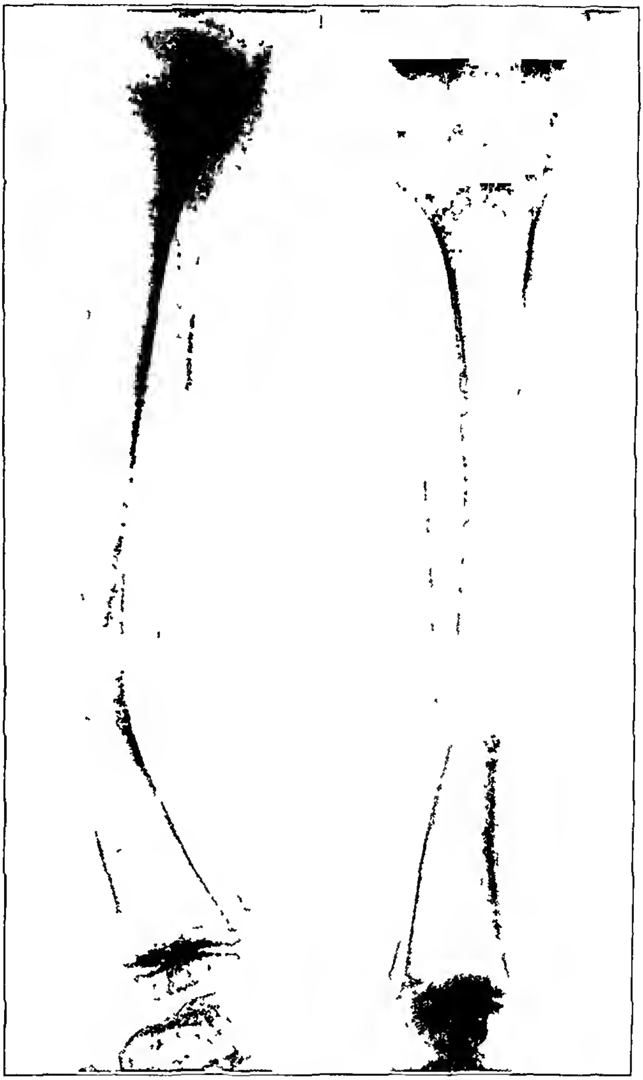

FIG 3-C

Case 2. Roentgenograms taken eighteen months postoperatively. There is solid bony union. A new medullary canal has been established across the fracture site. Defect in the fibula is still present Note the "hour-glass constriction" at the fracture site.

CASE REPORTS

CASE 1.* S. A., white female (Campbell Clinic No. 15366), was first seen on July 6, 1925, at the age of twenty-seven months. The anterior bowing of the leg was noticed during infancy, and fracture of the right tibia was first discovered at the age of fifteen months. The patient was placed in a cast for four weeks, and a brace for six months. The anterior and lateral bowing of the lower one-half of the tibia and fibula gradually increased. On admission, pseudarthrosis was demonstrated clinically and roentgenographically. In addition to the pseudarthrosis of the tibia, there was a defect in the

* Dr. Willis C. Campbell performed the bone graft on this child. The author is indebted to him for permission to include this patient in the series.

fibula (Fig. 2-A). From history and roentgenographic findings, the pseudarthrosis was probably secondary to a bone cyst.

July 10, 1925: A massive onlay bone graft was done, using a tibial graft from the mother. Six circular silver-wire loops were used to fix the transplant to the tibia. Cancellous bone was packed about the fracture site. The mother's and patient's blood were of the same group and compatible.

August 21, 1925: The wound had healed by primary intention, and a new cast was applied.

February 13, 1926: A roentgenogram showed that bony union had occurred, but that a medullary canal had not been established across the fracture site (Fig. 2-B).

May 22, 1926: Cast immobilization was replaced by a brace.

July 6, 1926: Roentgenograms revealed solid bony union. A new medullary canal was being formed through the fracture site. The silver wires were removed.

October 9, 1926: The patient was developing a slight knock-knee deformity, for which splints were fitted. Roentgenogram showed solid bony union. A new medullary canal had been established.

May 20, 1937: There was a valgus of 30 degrees of the right ankle, and 25 degrees of the left ankle (valgus of the left ankle was due to a congenital pseudarthrosis in the lower end of the left fibula). A supramalleolar osteotomy for correction of this deformity was advised.

February 22, 1938: A supramalleolar osteotomy was done to correct the valgus of the right ankle.

September 27, 1938: A supramalleolar osteotomy was done to correct the valgus deformity of the left ankle.

Following these procedures, both osteotomy sites healed normally.

October 22, 1940: At the age of seventeen, fifteen years after the bone graft, the right lower extremity was of the same size and strength as the left, except for three-eighths of an inch of shortening on this side. Roentgenographic examination revealed the right tibia to be of the same size and contour as the left (Fig. 2-C). Approximately 10 degrees of valgus of the ankles were still present. There was normal range of motion in the joints of both lower extremities. The patient walked without a limp, and carried on normal activities for a girl of her age. She stated that she was not handicapped in any way by her former pseudarthrosis.

CASE 2. H. L., a white male (Campbell Clinic No. 41036), first seen on May 25, 1937, at the age of two and one-half years. False motion and angulation of the lower third of the right tibia and fibula were present at birth. One operation for correction of the deformity had been done at the age of nine months. On admission, anterior bowing of the leg with free motion at the fracture site was present. Roentgenograms showed pseudarthrosis of the tibia and fibula.

June 21, 1937: The tendo achillis was lengthened and Hallock's operation was performed. The multiple chip grafts were removed from the mother's ilium.

July 25, 1938: Roentgenograms showed absorption of the chip grafts. There was free clinical motion at the pseudarthrosis (Fig. 3-A).

March 2, 1939: An onlay bone graft (from the mother's tibia) secured with vitallium screws was performed and cancellous bone packed about the fracture site. The mother's blood group was the same as the child's.

June 30, 1939: Roentgenograms revealed union of the graft to the proximal and distal fragments, and apparent beginning union at the site of pseudarthrosis (Fig. 3-B).

November 18, 1939: Roentgenograms revealed bony union at the site of the congenital pseudarthrosis. There was a tendency toward hemi-hour-glass constriction at the fracture site. A new medullary canal had not been established.

March 5, 1940: Roentgenograms showed union at the fracture site and beginning formation of a medullary canal.

May 10, 1940: The vitallium screws were removed under local anaesthesia.

September 26, 1940: Roentgenograms showed that the medullary canal had been

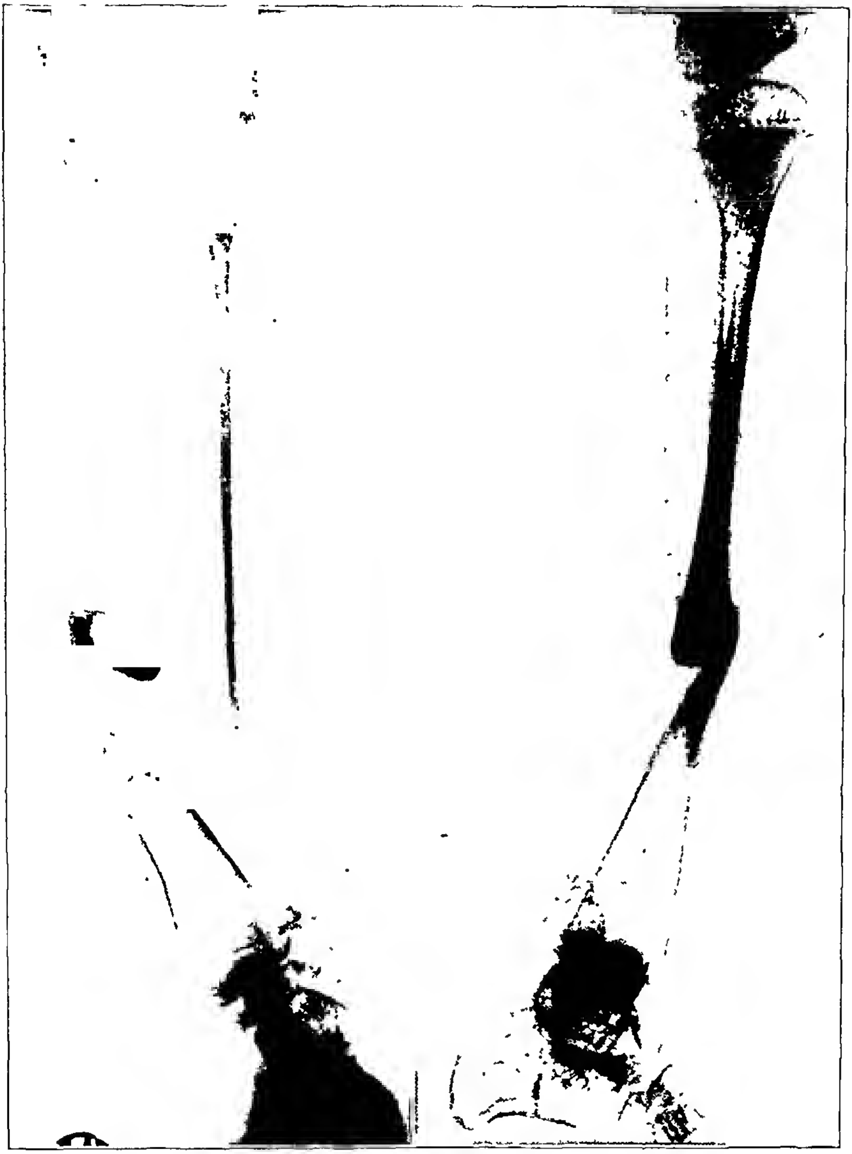

FIG. 4-A

Case 3. Preoperative roentgenograms show congenital pseudarthrosis of the left tibia with associated defect in the fibula.

established between the proximal and distal fragments. There was still a constriction at the fracture site (Fig. 3-C). The affected extremity was three-eighths of an inch shorter than the normal one.

CASE 3. W. J. W., white female (Campbell Clinic No. 46921), first seen on July 19, 1939, at the age of five years. Fracture in middle third of the left tibia was present at birth. A bone graft, using the fibula from the other leg, had been done at the age of one year. This was followed by cast immobilization for three years. On admission, there was anterior and medial bowing of the tibia and definite non-union both clinically and roentgenographically (Fig. 4-A). The left lower extremity was three-eighths of an inch shorter than the right.

July 22, 1939: Dual bone grafts were applied, using tibial bone from the father.

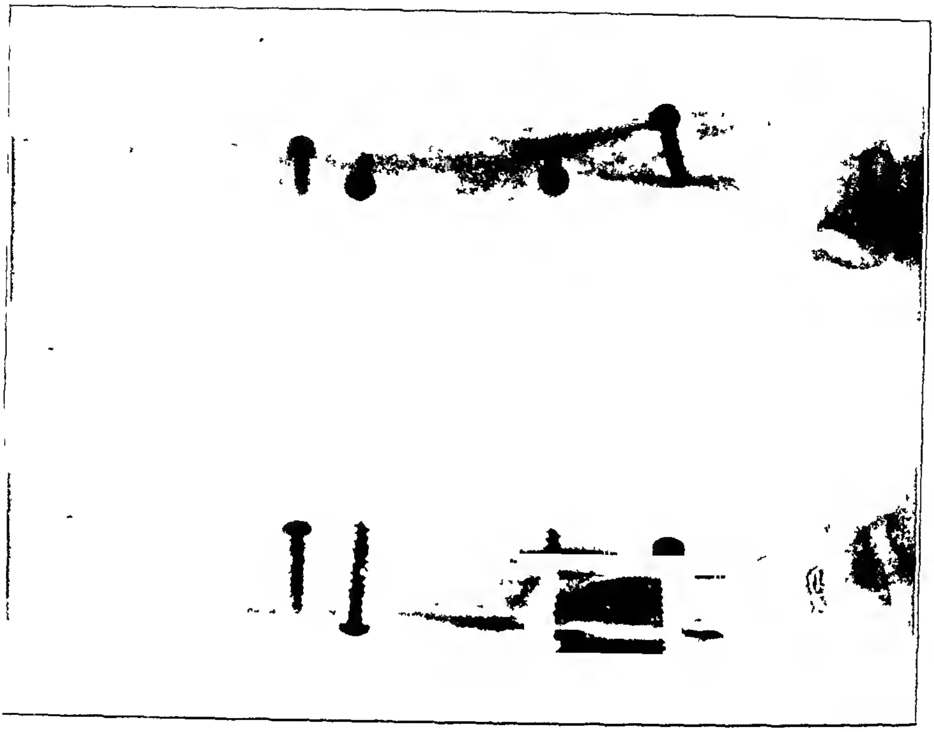

Fig. 4-C

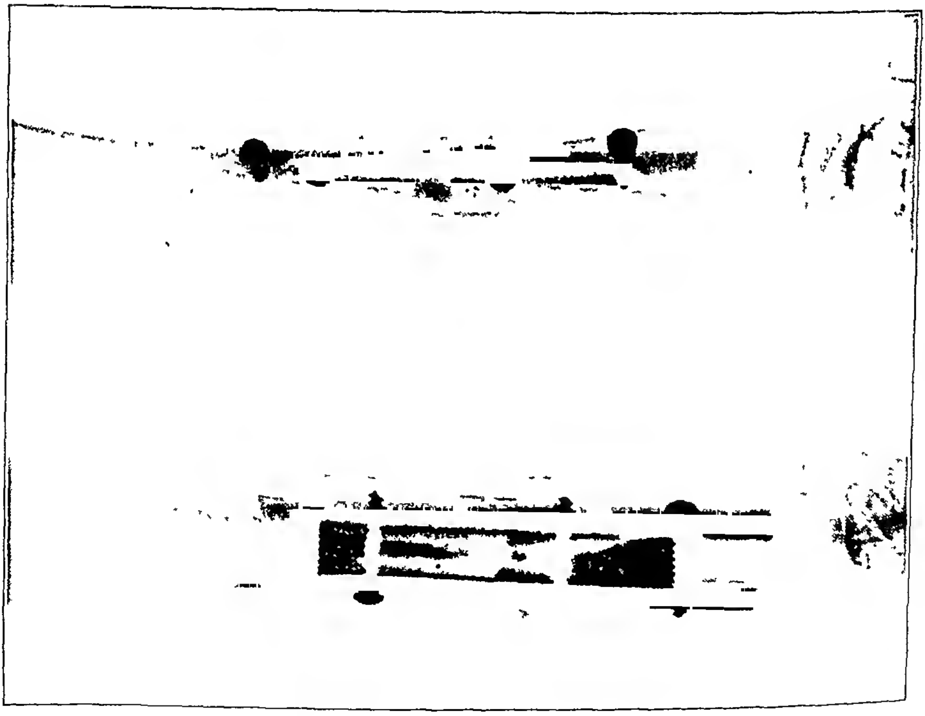

Fig. 4-B

Cancellous bone was packed about the fracture site and between the grafts (Fig. 4-B). The patient's blood grouping was Type IV; the father's was Type II, and not compatible.

September 8, 1939, and *January 26, 1940:* The cast was changed. Roentgenograms, taken on the latter date, showed absorption about the head of one of the screws in the tibial graft on the medial side (Fig. 4-C).

February 19, 1940: The screw mentioned above was removed under local anaesthesia and a new cast was applied.

April 5, 1940: A walking cast was applied.

May 14, 1940: The cast was removed. The fracture was clinically solid. A jointless leather lacer brace from groin to toes was fitted.

August 13, 1940: The pseudarthrosis was roentgenographically solid, but a new medullary canal had not been established.

December 27, 1940: The vitallium screws were removed under local anaesthesia. There were 15 degrees of valgus of the ankle. The affected leg was three-eighths of an inch longer than the normal. Roentgenograms showed bony union (Fig. 4-D).

CASE 4. R. L. D., white male (Campbell Clinic No. 35657), was first seen on March 25, 1935, at the age of three. From the history it was learned that the lower extremities had been apparently normal at birth. As the child grew, his parents noted a gradual anterior and lateral bowing of the left tibia. With the increase in deformity, a limp gradually developed. On March 21, 1935, at the age of three, while walking, the patient turned his ankle and noticed immediate pain in the lower third of the leg. Following this, he refused to bear weight on the leg.

Roentgenograms re-

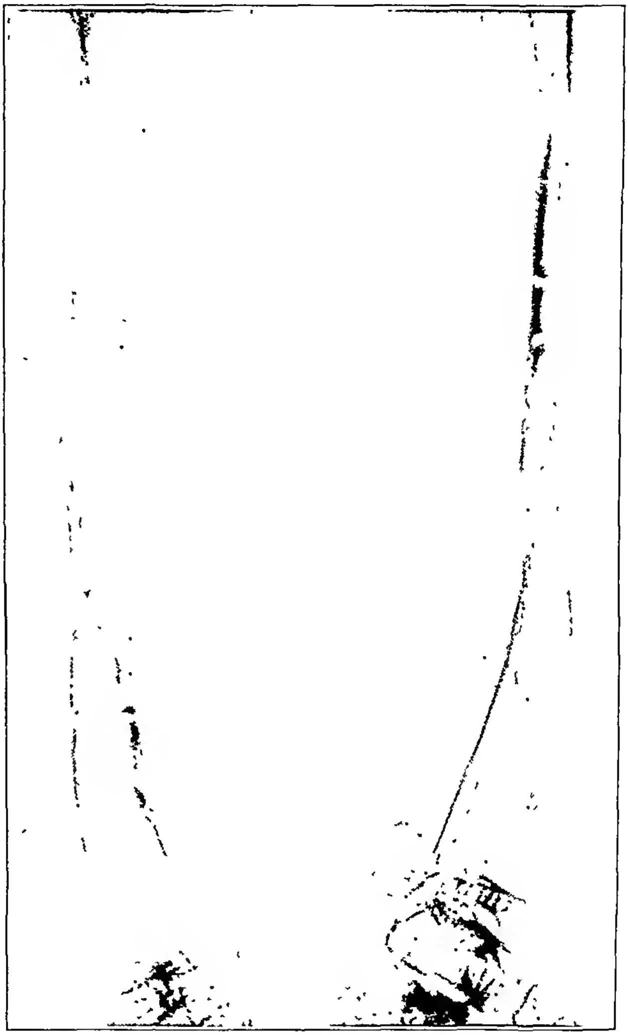

FIG. 4-D

FIG. 4-B: Case 3. Roentgenograms show dual bone graft immediately following the operation.

FIG. 4-C: Case 3. Roentgenograms taken six months postoperatively. Note the absorption of bone about the head of the proximal screw in the distal fragment. If this absorption occurred with a single graft, the result would probably be a failure. This screw was placed too close to the fracture site.

FIG. 4-D: Case 3. Roentgenograms taken seventeen months postoperatively. Screws were removed on this date. Bony union was present.

FIG. 5-A

FIG. 5-A: Case 4. Preoperative roentgenograms, showing pseudarthrosis of the left tibia. Roentgenograms taken prior to this date illustrate that the fracture occurred through a bone cyst.

FIG. 5-B: Case 4. Roentgenograms taken two months postoperatively, showing dual bone graft.

FIG. 5-C: Case 4. Roentgenograms taken seven months postoperatively. There is bony union at the fracture site.

vealed a fracture at the junction of the lower and middle thirds of the tibia, through a bone cyst.

March 26, 1935: A plaster-of-Paris cast was applied with the leg in as near normal position as possible without manipulation under an anaesthetic.

May 29, 1935: the cast was removed and a brace fitted.

November 16, 1936: A tenotomy of the tendo achillis was performed and the deformity partially corrected by manipulation. Skeletal traction was applied to correct the deformity gradually.

November 27, 1936: A long leg cast was applied.

May 13, 1937: The cast was removed, and a leather lacer brace applied.

September 20, 1939: The patient returned. He had not been wearing the brace. Pseudarthrosis persisted at the junction of the middle and lower thirds of the tibia. Angulation at the site of the fracture was 40 degrees (Fig. 5-A). The affected lower extremity was smaller and one-fourth of an inch shorter than the normal.

September 23, 1939: At the age of seven and one-half years, dual onlay bone grafts were applied, using tibial grafts from the mother. The blood grouping of the mother and patient were both Type II, and compatible.

November 15, 1939: Roentgenograms shows dual bone graft two months following the operation (Fig. 5-B).

January 26, 1940: Roentgenograms showed the beginning of bony union at the fracture site with union of the grafts to the tibia.

March 27, 1940: Cast immobilization was discontinued and a leather lacer brace applied.

April 17, 1940: Roentgenograms show solid bony union; however, a new medullary canal had not been completely established (Fig. 5-C).

July 5, 1940: Under local anaesthesia, the vitallium screws were removed.

September 18, 1940: Roentgenograms show solid bony union with reestablishment of medullary canal through the area of pseudarthrosis. The affected leg was one-half an inch longer than the unaffected leg (Fig. 5-D).

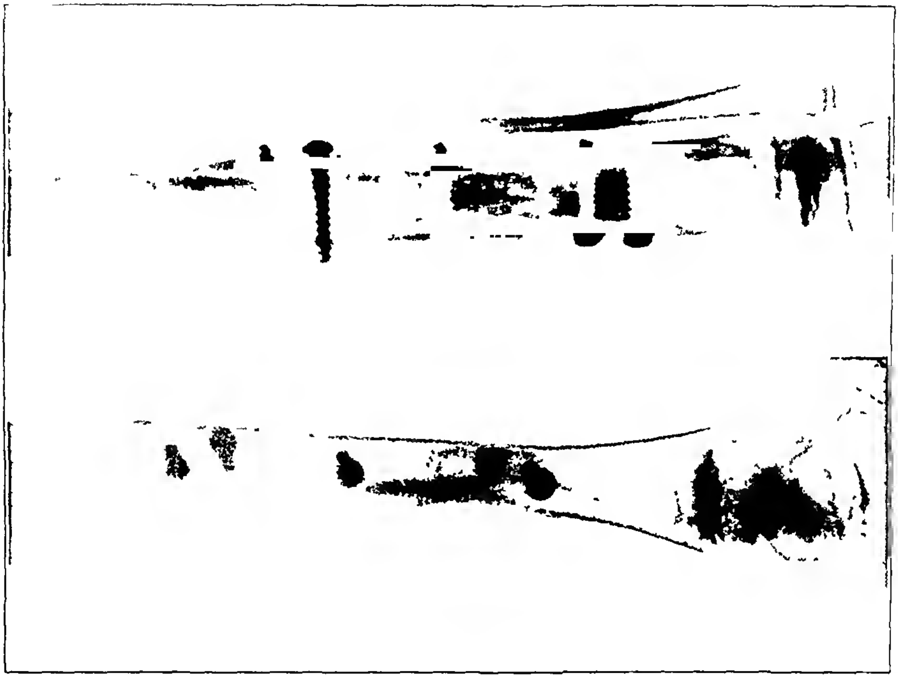

Fig 5-C

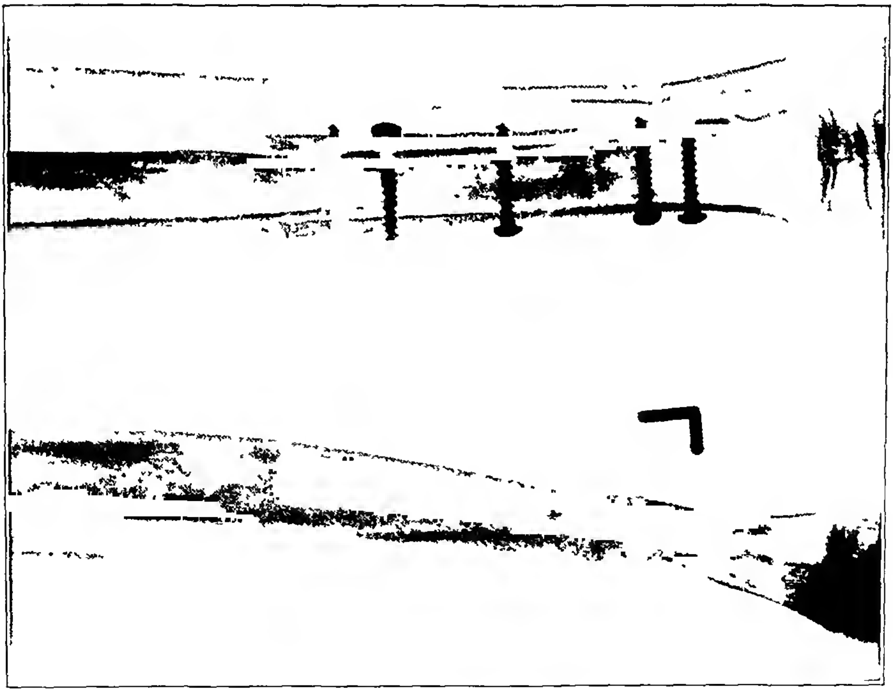

Fig. 5-B

FIG. 5-D

Case 4. Roentgenograms taken one year postoperatively. Solid bony union is present and a new medullary canal has been established across the fracture site.

RESULTS

In three patients with four single homogeneous grafts fixed by means of wire loops, one union was obtained (Case 1). Three consecutive patients in whom vitallium screws were used all have bony union. Dual grafts were used in the last two operated upon. One of these (Case 3) would probably have failed with a single graft as there was absorption about one screw head near the fracture site. These patients were operated upon fifteen years, twenty-one months, sixteen months, and fifteen months ago. One patient (Case 1) has a normal lower extremity for all practical purposes, and is not handicapped in any way. Three patients (Cases 2, 3, and 4) are walking in leather lacer braces at the present time.

It is too soon to report the final end result on the last three patients. From the present appearance of their roentgenograms, it is believed that all will ultimately have good weight-bearing extremities. The length of the affected lower extremities as compared with the sound side in the patients was as follows: Case 1, three-eighths of an inch shorter; Case 2, three-eighths of an inch shorter; Case 3, three-eighths of an inch longer; Case 4, one-half an inch longer. In the last three cases the leg lengths were checked with teleoroentgenograms. It is probable that the stripping of the periosteum near the epiphyseal lines to insert the dual grafts stimulated growth in Cases 3 and 4.

CONCLUSIONS

1. Bony union is more difficult to obtain in congenital pseudarthrosis than in any other type of non-union.
2. Union is more difficult to secure in younger than in older children.
3. If union can be obtained in childhood, the ultimate deformity and shortening of the leg are lessened or may be avoided.
4. The dual bone graft affords a sound mechanical procedure which should increase the percentage of bony unions in this condition.
5. The technique of the dual graft may also be used in the treatment of bony defects and in non-unions difficult to treat, resulting from causes other than congenital pseudarthrosis.

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THE USE OF SULFATHIAZOLE IN THE TREATMENT OF SUBACUTE AND CHRONIC OSTEOMYELITIS *

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This presentation is to be considered merely a preliminary report and in no sense as a finished investigation of the subject.

Hematogenous osteomyelitis is generally separated into three types,— acute, subacute, and chronic. This preliminary report deals primarily with the subacute and chronic forms, although two cases are included which might be considered acute.

Broadly speaking, in the past four types of procedure have been employed in the treatment of subacute and chronic osteomyelitis:

1. The conventional method of thorough débridement of the focus or foci, followed by repeated packing of the cavity with some form of material to provide drainage.

2. The maggot method of Baer in which, after thorough débridement of the focus, live maggots are introduced into the cavity. The maggots, acting as scavengers, remove all débris and produce a clean wound, which is allowed to heal by granulation, or is closed by secondary suture.

3. The Carrell-Dakin method, which consists in thorough débridement of the focus, followed by irrigation of the cavity with Dakin's solution every two hours, day and night, until the wound is free from infecting organisms, as demonstrated by laboratory methods. When the wound is sterile, secondary closure is made.

4. The Orr method in which, following thorough débridement, the cavity is packed with vaseline gauze and the region adequately immobilized in plaster and left undisturbed for long periods of time. This formula is followed until healing is complete.

It is not our intention to discuss the relative merits of these four methods of treatment, except to state that the first has been largely discarded by those who have had any considerable experience in the treatment of osteomyelitis. The Carrell-Dakin and Orr methods are those most generally followed today, with the Orr method decidedly leading in popular favor. Both the Carrell-Dakin and the Orr methods have definite disadvantages. The Carrell-Dakin method usually requires a long period of hospitalization and meticulous care in the daily dressings which are necessary. The chief objections to the Orr method, in the authors' opinion, are the long period required for healing, and the fact that healing is largely by scar tissue,—a real disadvantage in many locations. Recogniz-

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ing the disadvantages of the methods in use for the treatment of osteomyelitis, and having been impressed with the results reported by Key, Frankel, and Burford [1], following the implantation of sulfanilamide in contaminated wounds, the authors determined to try out sulfathiazole, administered by mouth and implanted in the wound, in the treatment of subacute and chronic osteomyelitis. Sulfathiazole was selected because it is a more effective agent than sulfanilamide against the staphylococcus, and so should be more effective in the treatment of osteomyelitis, in which staphylococcus is the infecting organism in 90 per cent. of the cases.

The plan of attack was based on the statement made by Key, Frankel, and Burford that powdered sulfanilamide in a wound is similar to a test-tube experiment in which a concentration of approximately 1,000 milligrams of the drug is brought into contact with any bacteria which may be present in the media. In such concentration, according to them, the sulfanilamide is effective against small numbers of staphylococci and of Welch bacilli, and against large numbers of streptococci. These authors, as the result of their work, concluded that when sulfanilamide is implanted in a wound, the drug exerts a neutralizing effect on the toxins present, thus minimizing the amount of tissue breakdown, and that the drug converts bacteria into a static or non-pathogenic phase in which they do not invade the surrounding tissues and do not multiply. In this static state, the bacteria are taken care of by the normal clearing mechanism of the animal and are destroyed. It was felt that if this premise was sound—and it seemed to be—a thorough débridement of the sinus and infected bone in subacute and chronic osteomyelitis, and the introduction of sulfathiazole powder into the wound should be effective in the same way against the comparatively small number of staphylococci and other contaminating organisms which would remain. An additional indication for the use of powdered sulfathiazole locally was the considerable evidence to show that pus is a definite depresser on the action of the sulfathiazole group, and that fibrous encapsulation of a focus makes it difficult for the drug to reach the focus through the blood stream in sufficient concentration to be effective. Both of these factors are present, to some extent, in subacute and chronic osteomyelitis; and consequently, the effect to be expected from sulfathiazole administered by mouth alone would be minimal.

The plan of treatment was: first, the administration of sulfathiazole for at least three days before operation in sufficient quantities to assure an average blood concentration of 4.7 per cent. (the purpose of this was to secure whatever benefit was possible from the presence of the drug in the blood stream); second, thorough débridement of the local focus and the introduction of powdered sulfathiazole into the wound. The local treatment was carried out as follows:

1. A tourniquet was applied to the extremity to be operated upon and kept in place until a cast was applied following the operation.

2. The sinus tract or tracts were injected with methylene blue for

the purpose of staining and so outlining all necrotic material in the soft parts and in the bone.

3. The sinus was completely dissected out down to the infected area in the bone.

4. The involved part of the bone was freely exposed and, using mallet, chisel, and gouge, all dead and necrotic bone, stained by the methylene blue, was removed, and the cavity saucerized as thoroughly as possible. The rough edges which remained were smoothed off by the use of an electric burr.

5. All scar tissue in the soft parts was dissected away as extensively as possible, thus providing healthy tissue which could be brought into contact with the bone cavity when closure was made.

6. One to two grams of sulfathiazole powder was then introduced into the wound, using a nasal insufflator.

7. The deep soft parts were then sutured with interrupted sutures in such a manner as to bring them into as close contact as possible with the denuded area of bone. Additional sulfathiazole powder was introduced into the wound and the superficial structures were closed with interrupted sutures. The skin was closed with cotton thread. A voluminous firm dressing was applied in such a manner as to press the soft parts firmly into the bone cavity. Finally, a plaster cast was applied, to adequately immobilize the extremity.

This treatment was first administered on August 1, 1940, since which time twenty-two osteomyelitic foci have been treated by this method. The following is a summary of the cases:

The number of hematogenous osteomyelitic foci treated was eighteen. The duration of the osteomyelitic process in the individual varied from nineteen years to thirty-seven days. The average duration was four and eight-tenths years. The duration of the activity in the particular focus treated also varied. The longest period of duration was two years, the shortest one week, and the average duration twenty-three weeks.

The drug was administered by mouth on an average of five and nine-tenths days before surgery and fifteen days after surgery. The average daily dose of the drug by mouth was 0.11 grams per kilogram or five grams per 100 pounds of body weight. The range of blood concentration during administration by mouth was from one to thirteen milligrams per 100 cubic centimeters. The average blood concentration on the day of operation was 4.7 per cent.

The results were as follows: Fourteen of the eighteen cases, or 78 per cent., healed by primary union; two, or 11 per cent., did not heal; and two, or 11 per cent., have been too recently treated to report. The average length of time from the day of operation to healing was twenty-one days. In many of these cases, approximately 50 per cent., there was some superficial breaking down of the skin incision, not in its entirety but at one or two points. These areas healed within one to two weeks in all cases.

The two unhealed cases are of interest. The first of these was an

osteomyelitis of the mandible, which apparently healed. Within a week following apparent healing, there developed a discharging sinus which, when probed, did not seem to lead down to bone, but which continued to discharge. The authors are unable to offer any explanation for this situation, since osteomyelitis of the mandible ordinarily heals rapidly. The second case was one in which the infection was due to the bacillus coli, determined before surgery was undertaken and at the time of operation. The inefficacy of sulfanilamide and sulfathiazole against bacillus coli is well recognized, and was certainly demonstrated in this case. The authors believe that a proved bacillus coli infection should not be treated by this method. This case is now being treated by the Carrell-Dakin method, and, as soon as the colon infection is cleared up, the wound will be closed by secondary sutures and powdered sulfanilamide or sulfathiazole introduced into the wound. In one acute case the wound was opened and drained for thirty-seven days, and then closed, using sulfathiazole powder. This wound closed by primary intention and has remained closed. A second case, which had some of the characteristics of an acute case, was of a boy whose original focus, in the lower end of the femur, had been healed for five months. The new focus was in the upper third of the femur, entirely separate from his original focus. When seen, the abscess had ruptured through the periosteum, and the thigh was distended with pus which had infiltrated between the muscle planes, forming many pockets. This case after débridement was treated by the Carrell-Dakin method for ten days. At the end of ten days, secondary closure was carried out, using sulfathiazole powder in the wound. This wound healed by primary intention in three weeks and has remained closed for two and a half months.

In addition to the eighteen osteomyelitic foci of hematogenous origin, four cases, in which the osteomyelitis followed a compound fracture, have been treated by this method. In these four cases, the longest period during which infection had been present was four years, the shortest was forty-one days, and the average was nineteen months. In all four cases healing was complete. The average length of time between surgery and healing was twenty-six days. The blood concentration of the sulfathiazole and the amount of powder used locally was the same as that in the cases of hematogenous osteomyelitis.

If the four cases of osteomyelitis following compound fracture are added to the eighteen cases of hematogenous osteomyelitis, the series reported includes twenty-two cases. Of the wounds in these twenty-two cases, eighteen, or 82 per cent., healed; two, or 9 per cent., failed to heal; and two, or 9 per cent., are too recent to report. The average length of time required for healing after operation in these twenty-two cases was twenty-three days.

CONCLUSIONS

1. A series of twenty-two foci of subacute and chronic osteomyelitis is reported in which the treatment employed was the administration of

sulfathiazole by mouth, thorough débridement of the focus, and the introduction of sulfathiazole powder into the wound. In 82 per cent. of the cases in this series, there was healing by primary intention with an average healing period of twenty-three days following surgery.

2. This is a comparatively small series of cases, and no attempt can be made from it to arrive at a final conclusion as to the value of the method proposed. However, the results have been sufficiently satisfactory, both in regard to the type of healing and the healing period, to suggest that the method should be given a thorough trial.

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A METHOD OF CORRECTING THE DEFORMITY IN SCOLIOSIS BEFORE PERFORMING THE FUSION OPERATION

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The most satisfactory method, at present available, of treating cases of scoliosis, particularly those cases where the deformity is already fairly marked and almost certain to become worse, is the method that has been developed over a period of years at the New York Orthopaedic Hospital.[1,2,3] There are three main principles that govern this method of treatment: first, to find out which is the primary curve; second, to make this primary curve as straight as possible; and finally, to stiffen this curve *permanently in the straightened position by a fusion operation.* All these principles are excellent.

The most difficult part of the whole treatment is the straightening of the primary curve. In most cases for which this method is used, the primary curve has become so stiff that it cannot be straightened completely. It can be improved a good deal, particularly towards its ends, by bending the spine in the opposite direction, but there is a limit to the amount of improvement that can be obtained. As far as the author has been able to find out by using different amounts of bending force and observing their effects by roentgenograms, increasing this force straightens the curve until a certain point is reached, when the correction stops rather suddenly. Any greater force will not produce any further correction of the primary curve, although it may increase the more flexible secondary curves. The Risser jacket, as used at the New York Orthopaedic Hospital, can, by its turnbuckle, be made to exert a great deal of force, but this great force is not necessary, and is sometimes dangerous. Once the limit of correction is reached, and there is no further yielding of the spine, strong pressure comes against the skin and, if the turnbuckling is continued beyond this point, a pressure sore will result. It is difficult to tell when the limit of correction has been reached and when the skin has been subjected to as much pressure as it will stand. In using the turnbuckle, one is apt to go too far and produce a sore or, from caution, to stop too soon and fail to obtain all the correction possible. Besides this difficulty in knowing how far to go with the turnbuckling, there are other objections to the Risser jacket. The whole method seems unreasonably complicated, requires a great deal of attention, and takes a fairly long time before the patient is ready for the fusion operation. Further, during the process of correction, the jacket is bent around one point, whereas the body bends at several levels. The shape of the jacket and that of the body change differently and, in the final position, the position in which the patient has to remain for a long time, the jacket does not fit, and may cause undue pressure on two or three points.

In an attempt to overcome these objections to the turnbuckle jacket, the author has, in the past two and a half years, been doing the correction in a different way. The patient is placed on his side in a net hammock, and the two ends of the hammock are slung up to the ceiling with the body bent rather sharply in a direction to correct the primary curve (Fig. 1). He is placed in the hammock for an increasing length of time each day until he becomes used to the bent position. While he is hanging in the hammock in this position, a plaster is applied which extends from the head to one foot (Figs. 3 and 4). A window is cut in the back of this plaster and the patient is ready for the fusion operation. No further alteration in the plaster is necessary, and the patient is kept in the same plaster in the same position until about three and a half months after the operation.

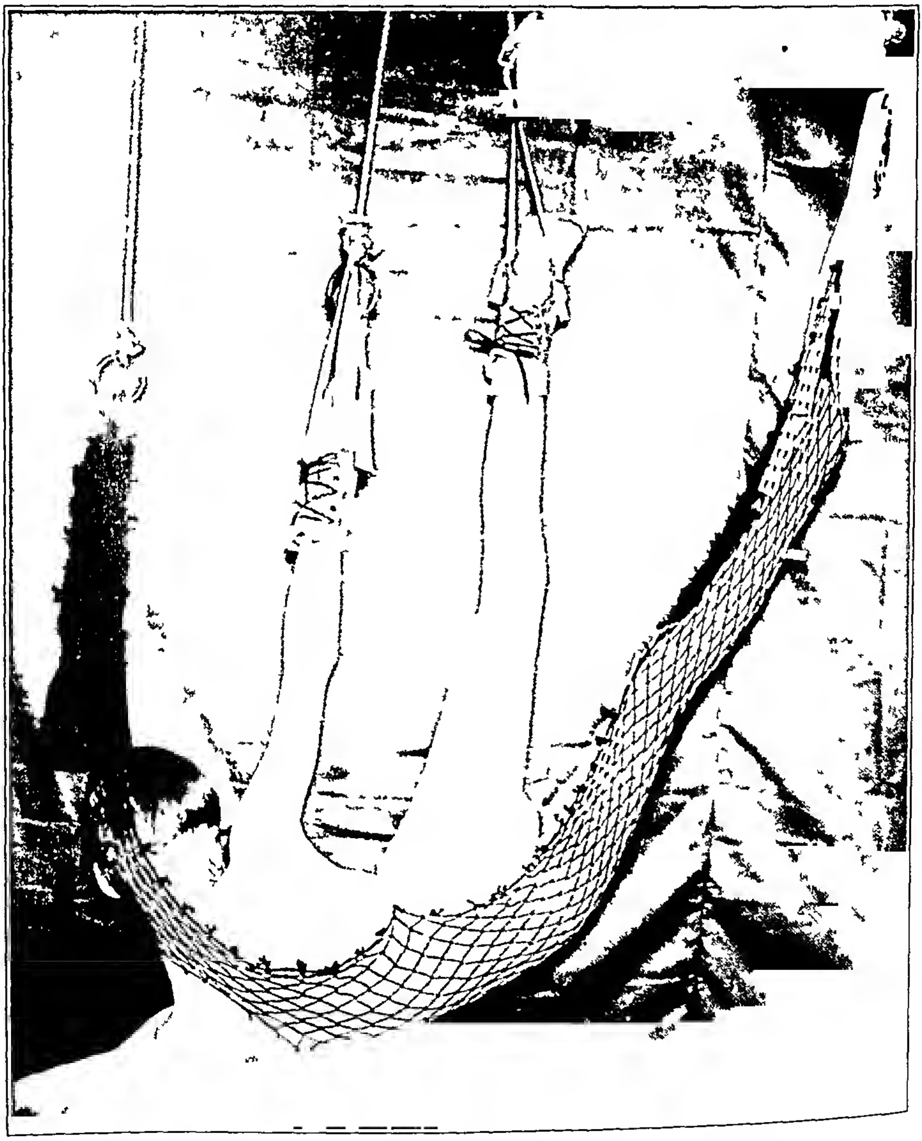

Fig. 1
Patient suspended in hammock, ready for application of plaster.

This method is no more efficient in correcting the primary curve than is the Risser jacket, but the author believes that it is just as efficient and that it has certain advantages. Several attempts have been made to obtain more correction of the stiff curves than can be obtained by the hammock alone, but without success. In one case the jacket, applied with the patient in the hammock, was converted into a hinged jacket, and bent further by a turnbuckle. Roentgenograms showed that none of this increased bending took place in the primary curve. The patient soon developed a pressure sore with the turnbuckling, and the method was therefore not tried again. It was thought that, by prolonged stretching of the shortened structures on the concave side of the curve, it might be possible to increase the amount of correction. Several patients were placed in

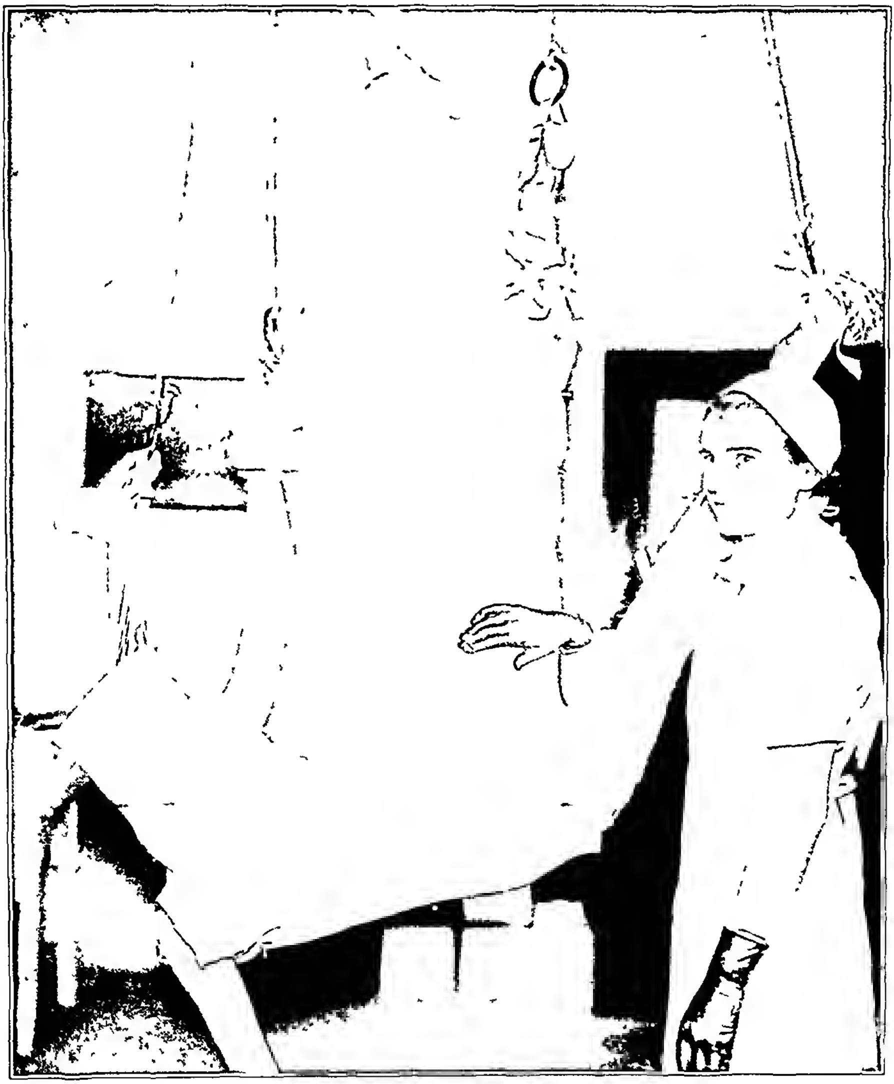

FIG. 2
Application of sponge-rubber padding.

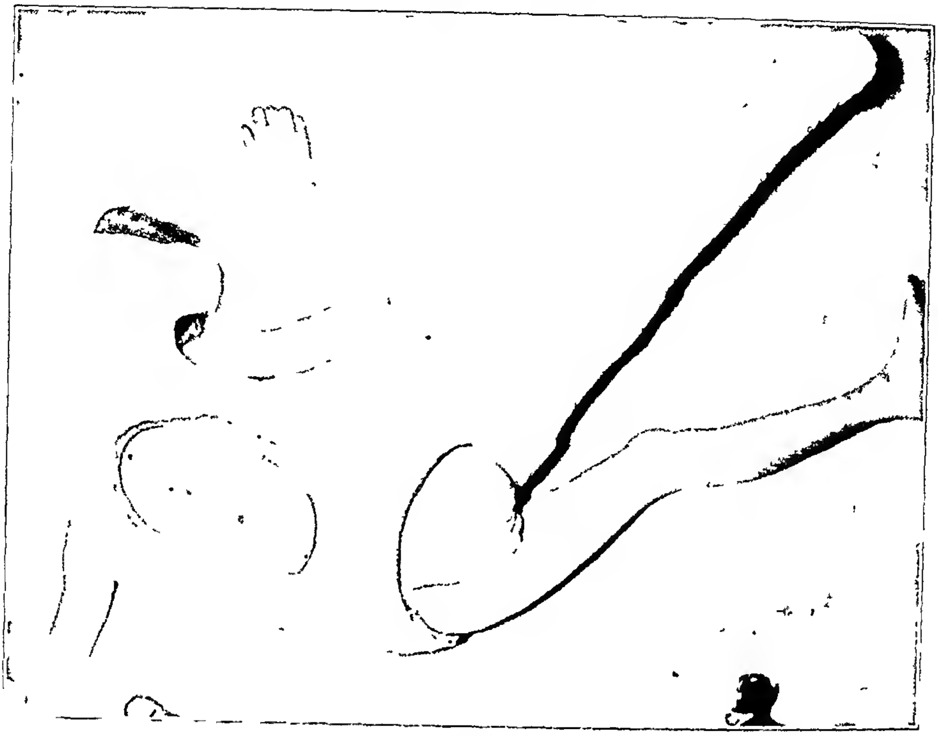

FIG. 3
Completed jacket from the back.

the hammock for as long as two hours a day for three or four weeks, but the roentgenograms taken in the hammock did not show any increase in the correction after the first few days. It was also thought that fixation for a while in the position of extreme correction might result in enough softening of the resistant structures to allow further correction. Two patients were put in plaster in the hammock, and in about three weeks' time the plaster was removed. After being placed in the hammock for two or three days more, another plaster was applied, with no further improvement in the primary curve.

The author is, therefore, convinced that the stiff primary curves can be corrected to a certain limit by a moderate amount of bending force, and cannot be corrected further by any reasonable force that the patient can stand. The amount of bending force required to correct the curve to its limit can be as well obtained in the hammock, as it can with the turnbuckle jacket, or with any other mechanical force applied externally.

This hammock method has certain advantages over the turnbuckle jacket. It is much simpler, and, aside from the supervision necessary during the preliminary daily suspension, requires very little attention. The application of the plaster, with the patient in the hammock, is easy, and, once the jacket is applied, it needs no further alteration. In the hammock, it is fairly easy to tell how much bending the patient will stand, and it is comparatively simple to adjust the position so that the maximum amount of correction is obtained, without undue discomfort, and without

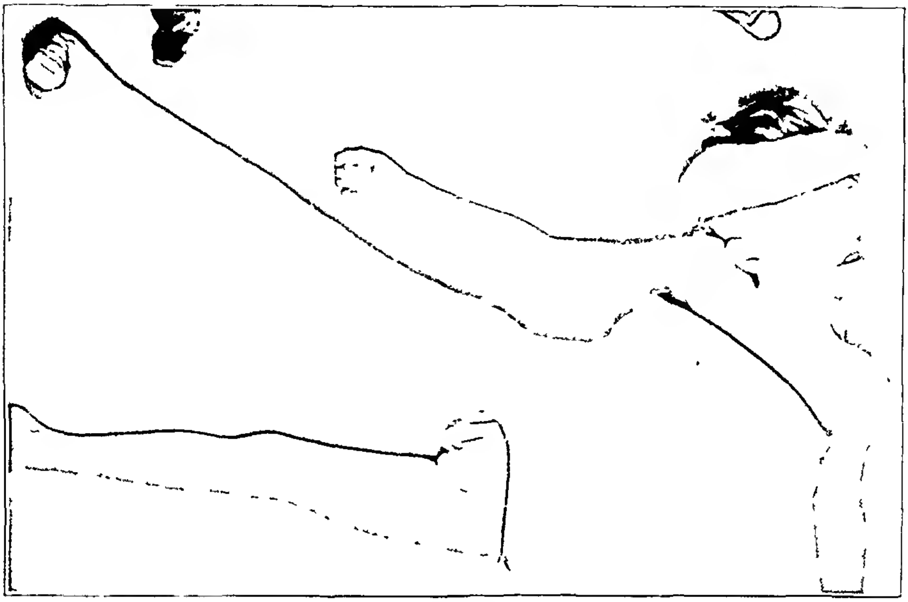

Fig. 4
Completed jacket from the front.

undue pressure of the plaster on the skin. The plaster is put on with the patient in the final position and should fit accurately during the whole time that it is on. It is comfortable and there has been no trouble with pressure sores. The jacket applied in this way is much less bulky than the turnbuckle jacket, which is a help when roentgenograms are taken and during the operation. The main advantage is that the method is quicker, and the amount of time taken to get the patient ready for operation is considerably shortened.

There are several details that have been learned about the use of the hammock. The net is the ordinary fish net, with about a one-inch mesh, and should be made of cord that has very little yield to it. The net stretches in length when the patient is placed in it, but there should be no further stretching once the application of the plaster is started. The strip of net should be long enough to extend well beyond the patient at either end, and should be about sixteen inches wide before the patient is put in it. If it is too wide, it is difficult to pull out from under the plaster, and, if it is too narrow, the patient may slip out of it. The hammock is suspended by its two ends over pulleys, which are so arranged that the distance between them can be altered. The whole suspending apparatus should be strong and, as a further precaution against accident, a stretcher should be kept under the patient when he is in the hammock. The bending of the patient is brought about by the force exerted chiefly on the head and on the lower of the two legs. The upper arm and upper leg are also suspended, but only enough pull is applied to these to keep the body from rotating. The lower arm hangs through a hole in the hammock, and may be allowed to rest on the stretcher beneath.

The position in which the patient is suspended, when the plaster is applied, is important. In the hammock, the bending takes place along the whole length of the spine, but mostly at the part of the spine that is lowest when the patient is in the hanging position. The point of maximum bending can be shifted toward the upper part of the spine by raising the leg end of the hammock, or shifted toward the lower part by raising the head end. The maximum bending should take place at, or slightly below, the apex of the primary curve, and the hammock should be so suspended that this part of the spine is the lowest part. To obtain the maximum correction of the curve, the two ends of the hammock should be as close together as the patient will stand without undue discomfort. When the patient is first put in the hammock, this bending is uncomfortable, and is resisted by the muscles. The first suspension should last for only a short time and should be done with the ends of the hammock fairly far apart. The patient soon gets used to the position, and the length of time is increased each day with the ends of the hammock brought closer together. It will be found that there is a definite limit to the amount of bending that each patient will stand, and there is no way of extending this limit. When the ends of the hammock are brought close enough together to cause marked discomfort, and when the tendency to rotate the body becomes uncontrollable, it means that too much force is being applied, and prolonged suspension in this position will not make it any more tolerable. The ends of the hammock are then separated slightly, until the patient is reasonably comfortable, and this position is accepted as the best position obtainable. Exactly the same position is maintained for any further use of the hammock that is necessary, and for the application of the plaster. Figure 1 shows the patient suspended in the hammock in the best possible position for a stiff curve with its apex at the seventh thoracic vertebra. The suspended ends of the hammock are as close together as the patient will stand, and the foot end is enough higher than the head end to bring the maximum bending force to about the level of the seventh thoracic vertebra. If the ends are any closer together, the patient will have a good deal of discomfort while in the hammock, and this discomfort will persist for some time in the plaster, without any improvement in the position. If the apex of the curve is at the ninth thoracic vertebra, the head end of the hammock should be relatively higher than shown in the photograph. If the foot end is much higher than shown, the cervical spine will be rather sharply bent, and the brachial plexus may be injured by stretching. The position of the spine obtained in the hammock can easily be shown by roentgenograms taken with a portable machine. As a rule, during the last two days roentgenograms have been taken with the patient in two slightly different positions, to determine which position is the best. It takes, on an average, about a week or ten days of being placed in the hammock, before the patient can stand it for a long enough time to have the plaster applied.

With the patient hanging in the hammock, the actual application of

Fig. 5-A

Congenital scoliosis Position before treatment, patient standing

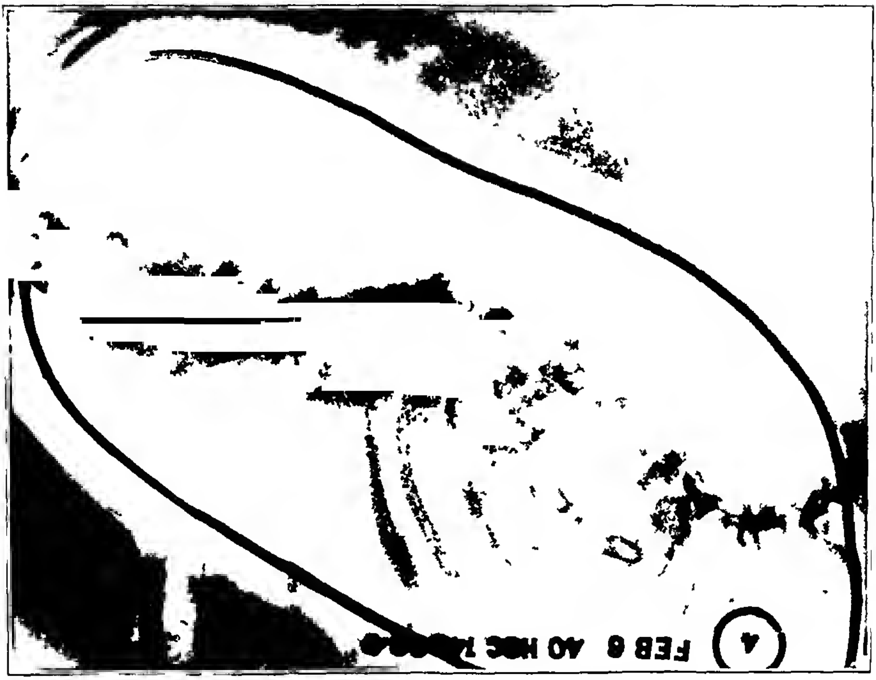

Fig. 5-B

Preoperative roentgenogram of the patient in plaster, showing correction obtained in the hammock

Fig. 6-A

Paralytic scoliosis. Position before treatment, patient standing.

the plaster is comparatively simple. If the net is to be pulled out afterwards, it should be placed next to the skin. The only padding used is a single layer of porous sponge rubber, about half an inch thick. This has proved to be very satisfactory and comfortable, and, even in hot weather, causes no trouble with the skin. It is obtained in sheets about three feet square, which are cut to fit the patient fairly accurately, and are held in place by a few stitches (Fig. 2). It is somewhat elastic, and adapts itself fairly well to the contour of the body in the bent position. When the plaster is completed, the rubber is turned over at every edge and fixed by a few stitches and by additional turns of plaster. Putting on the sponge-rubber padding adds somewhat to the time and trouble taken for the ap-

Fig. 6-B

Preoperative roentgenogram of the patient in plaster, showing correction obtained in the hammock.

plication of the jacket, but, as the patient has to lie in the jacket for three or four months, the additional comfort makes it worth while. The lower part of the plaster is applied in much the same manner as a hip spica, extending upward to just below the axillae. Several turns are then put around the head just above the ears, and this head piece is joined to the plaster over the back by a slab of plaster, wide enough to allow the upper part of the window to extend into it, and strong enough at its edges to keep from breaking. The leg that is high with the patient in the hammock—that is the one on the convex side of the original primary curve—is the one included in the plaster. In most cases the whole length of the leg and the foot are included. This is done because, with the plaster ending above

the knee, the pelvis sometimes tilted within the plaster, and some of the bending obtained in the lower part of the spine was lost. To prevent this downward tilting of the pelvis on this side, the plaster was extended to include the foot, and was applied with a moderate upward push on the sole. These patients usually sleep on their back, but prefer to spend most of the day on their side, with the leg in the air. The inclusion of the knee in plaster makes this position more comfortable. The plaster extending from the head to one foot is surprisingly comfortable and very efficient, and none of the bending obtained by the hammock is lost as long as the plaster is on.

The whole subject of the treatment of scoliosis by correction and fusion was very well described in the paper by Smith, Butte, and Ferguson. In that paper two points were mentioned which are not always followed, but which are important enough to emphasize. One is that if the primary curve cannot be completely straightened, the fusion should be extended upward and downward into the compensatory curves, until vertebrae are reached that are parallel and centered in the same line. If this is done, the fused part of the spine is made into a solid block of bone which may not be straight, but which has its top and bottom surfaces parallel and in line. This is much better than the more or less wedge-shaped block of bone produced if the fusion does not extend far enough. The other point is that the fused part of the spine should be protected against bending for a long enough time after the operation to allow the fusion to become solid. In the Hibbs operation [1], the available bone has always seemed insufficient in amount, and, for some years, the author has been adding to this bone by cutting several long thin sliver grafts from the tibia. These grafts are placed in the gutter, under the bone flaps raised from the sides of the spinous processes and backs of the laminae, and are so placed that they overlap each other. In children at any rate, this method produces a large column of bone that in time becomes solid, and the author thinks that, with it, a pseudarthrosis is less likely. When two fusion operations have to be done, the likeliest point for pseudarthrosis is the junction of the two. To avoid this, at the first operation the author has extended the fusion about two vertebrae farther on one side than on the other so that, finally, the junction of the two fusions will be at different levels on the two sides. No matter how the fusion is done, it will be a long time before it is solid, and the spine should be protected until it is solid. The original bent jacket, applied in the hammock, is removed three and a half months after the last fusion operation, and then a shorter and straighter jacket is applied, in which the patient is able to walk about. A jacket ending below the armpits provides practically no support to a curve of the usual level. To the jacket should be added a loop of plaster over the shoulder that keeps the neck bent slightly in the same direction as the original plaster. This straighter jacket should be kept on for a varying length of time, depending on how much bending strain there is. If there is a considerable amount of curve still present, and if there is much muscle paraly-

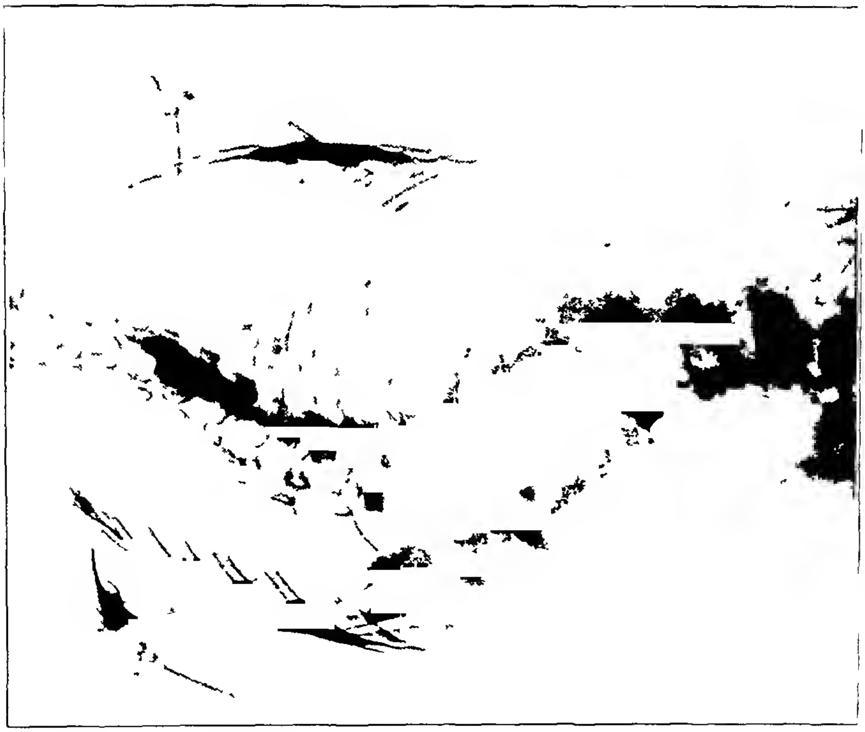

Fig 7-A

Idiopathic scoliosis Position before treatment, patient sitting

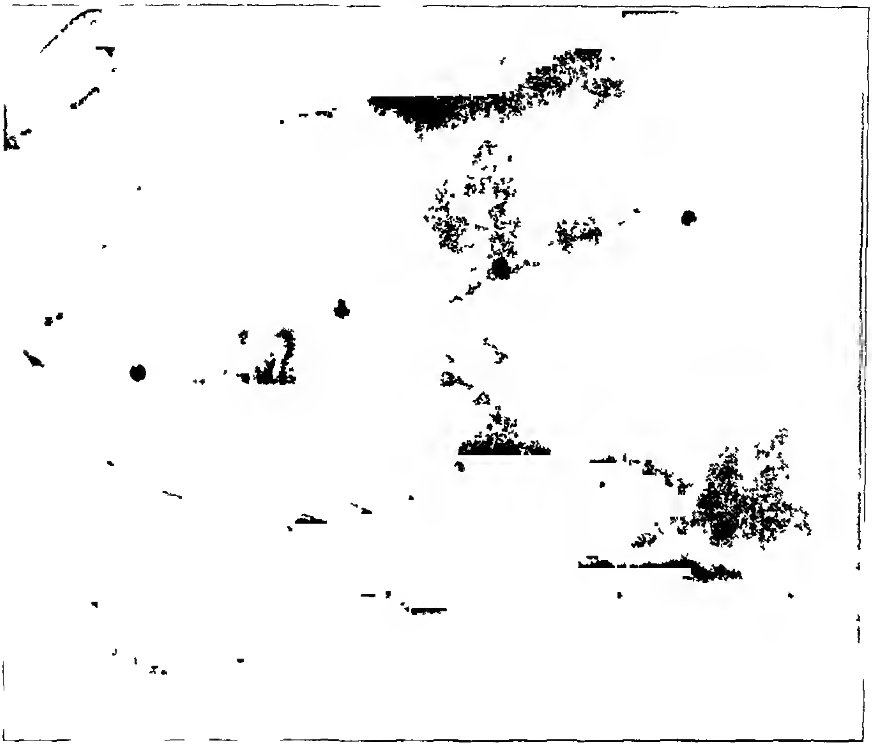

Fig 7-B

Preoperative roentgenogram of the patient in plaster, showing correction obtained in the hammock

sis, the support should be continued for a long time, sometimes as long as a year and a half. If the curve has been completely straightened, and there is no muscle paralysis, the jacket is continued for at least seven months after the last fusion operation.

The only thing really new offered in this paper is the use of the hammock for the correction of the curve, and for the holding of the patient while the plaster jacket is being applied. This method has been used in twenty-seven cases and has been found to be considerably more satisfactory than the turnbuckle jacket.

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FRACTURE-DISLOCATIONS OF THE HIP JOINT

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HISTORY

Before the advent of the automobile and the roentgen ray, dislocations of the hip associated with fractures of the acetabular lip held a fascination for the surgeon largely because of their rarity. Diagnosis could be established with certainty only by postmortem examination, and consequently the lesion was rarely recognized.

The first authentic cases of fracture-dislocation of the hip, which were verified by autopsy examination, were reported by Sir Astley Cooper in 1805. Malgaigne, in 1850, reviewed the twelve cases which had been previously reported, and postulated that the condition should be suspected if crepitation could be felt on manipulating the dislocated hip, or if the head tended to redislocate readily after its initial reduction. Thirty years later, in 1880, Senn, in a report based on twenty-seven clinical cases and experimental work on the cadaver, concluded that extreme violence was necessary to fracture the acetabular rim. Crile, in 1891, reported the first case of a dislocation of the hip joint, with fracture not only of the acetabular lip, but also of a portion of the head of the femur. Since the advent of roentgenography, fracture-dislocations of the hip have been reported with increasing frequency, notably by Stimson, Hamilton, Gatewood, Wheeler, Lenormant, Koven, Henderson, and more recently by Cubbins, Conley, and Callahan, and by Grinda.

In 1927 Breton and Blondeau pointed to the increasing frequency of this lesion in automobile accidents, and gave it the name "automobile injury" of the hip joint. Nine years later Campbell reported eighty cases of posterior dislocation of the hip, thirty, or 37.5 per cent., of which were the typical fracture-dislocations with which the authors are concerned in this paper.

In 1938 Funsten, Kinser, and Frankel reviewed twenty cases of dislocation of the hip, which they had followed for at least three years. Thirteen of these were due to automobile accidents, and in nine cases the acetabular rim was fractured. The results were good in eleven cases; aseptic necrosis of the femoral head developed in six patients, three of whom had to be operated upon later. These authors concluded that immediate reduction with traction gives good results; and that the longer the dislocation persists before reduction, the poorer the prognosis.

The clinical studies of Dyes, Stewart, Phemister, Obwegeser, Pfab, Kleinberg, and Potts and Obletz have demonstrated that the most

frequent complications of this lesion are traumatic arthritis and aseptic necrosis of the femoral head. Myositis ossificans and injury to the sciatic nerve occasionally occur.

Fig. 1-A

Fig 1-B

Fig. 1-A: Experimental fracture-dislocation of the hip in a dog.
Fig. 1-B: Twenty-two weeks later there is marked restriction of movement.
Fig. 1-C: Experimental fracture-dislocation of the hip after twenty-two weeks There is a large amount of new bone around the acetabulum, and marked generalized fibrosis. The head is riding in a new acetabulum posterosuperiorly, and is covered with fibrous tissue except in one small area anteriorly, where it is eburnated and polished.

FIG. 1-C

FIG. 1-D

Section through the head shows complete disappearance of articular cartilage, thickening of the cortex, and fibrosis of the marrow spaces.

Fig. 2-A

Experimental fracture-dislocation in the hip of a dog.

MECHANISM

In a few cases this injury has resulted from a fall on the flexed knee, usually from a height. In the majority of cases, however, the injury has been received in an automobile accident. Characteristically the patient is seated with knee and hip flexed to 90 degrees, and is thrown suddenly forward, so that the knee strikes against the instrument panel.

The tremendous force with which a person may be thrown against the instrument panel (or against the back of the front seat if he is riding in the rear seat) is well illustrated as follows: The kinetic energy of a 150-pound body moving forty-five miles per hour is 10,200 foot pounds.* In bringing this moving body to rest, the same amount of energy must be expended (10,200 foot pounds is equivalent to five tons falling one foot).

That an enormous force is required to produce the lesion is also suggested by the inability of various workers to produce it experimentally by direct blows on the flexed knee of the cadaver. Senn, in 1882, had one success in seven experiments, Allis in 1896, Virevaux in 1899, Fox and Schroeder in 1909, and King † in 1938 were unsuccessful.

The force of the blow may be spent in disrupting the knee joint, fracturing the femoral shaft, or driving the femoral head out of, or through the posterior wall of the acetabulum. As the head is driven out of the

* Calculations by Mr. Hackney:

$$\frac{1}{2} \times \frac{W \times v^2}{32} = \frac{150 \times (66)^2}{32} = 10{,}209$$

This figure is for a sudden complete arrestment of movement. In an automobile accident there are, of course, many variables,—such as speed of motion, weight of the patient, friction against the seat, distance in which the car motion is stopped, resistance of object struck, etc.

† Experimental work unpublished.

acetabulum into a posteriorly dislocated position, a variety of fractures may result. The three common ones are:

1. Posterior lip fracture.
2. Sprain fracture of the femoral head (a small fragment of the head attached to the round ligament remains in the acetabulum).
3. A transverse fracture across the floor of the acetabulum.

Fig 2-B

Roentgenogram shows result sixteen weeks later

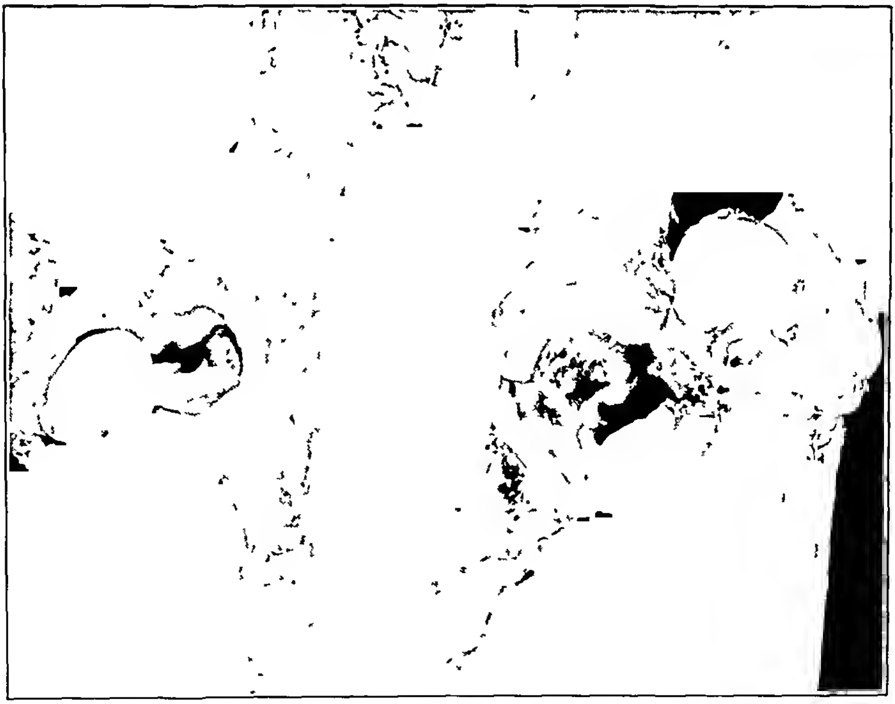

Fig 2-C

There is marked degenerative arthritis The head is in a false acetabulum, and there is no cartilage on the head which is markedly eburnated and polished.

The importance of correcting the slightest incongruity of articular surfaces resulting from joint fractures has been recognized and repeatedly emphasized for many years. This is particularly important in fractures into the joints of the lower extremity where weight-bearing

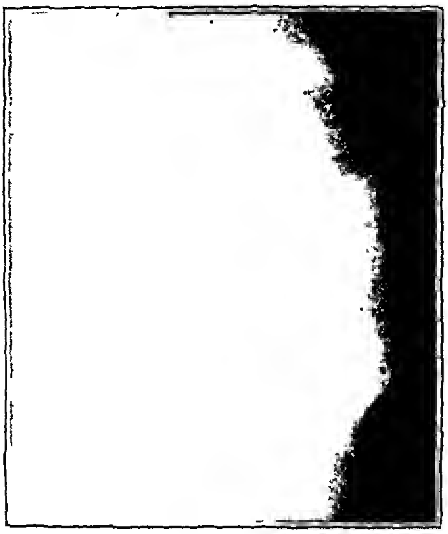

Fig. 3-A

Fig. 3-B

Fig. 3-A: Case 1. Posterior dislocation of the left hip with a large *fragment of* acetabular lip.

Fig. 3-B: The dislocation of the head is satisfactorily reduced, but the lip fragment is not in position. Note that its articular surface lies about a centimeter above the arc of the main body of the articular surface.

Fig. 3-C

Fig. 3-D

Fig. 3-C: Posterior view one year later. The loss of joint space is apparent, due to recurrence of the subluxation. The hip is painful and stiff.

Fig. 3-D: Roentgenogram shows the result after fusion.

Comment: The large acetabular lip fragment was not satisfactorily replaced, and reduction was unstable. On weight-bearing gradual subluxation occurred, with disintegration of the joint necessitating fusion.

Operative Findings: There were posterior subluxation of the head, fibrous union of the lip fragment in poor position, and loss of the articular cartilage from the head with much fibrous tissue in the acetabulum. No attempt was made to reduce the head completely into the acetabulum. It was fused with a Smith-Petersen nail.

Fig. 4-A

Case 2. Posterior dislocation of the left hip with lip fragment, and sprain fracture of the head.

Fig. 4-B

Posterior view of the reduction accepted by attending surgeon as satisfactory.

Fig. 4-C

Result three years later. The hip was stiff and painful, necessitating fusion.

Comment: Reduction was poor. The inferior surface of the head was not snugly in the floor of the acetabulum, due to imperfect reduction of the head fragment. The acetabular lip fragment was not replaced. Recurrence of subluxation on weight-bearing was followed by disintegration of the joint.

makes them especially prone to the development of degenerative arthritic changes.

The rapid disintegration which occurs in a hip joint following incomplete reduction of a fracture-dislocation is demonstrated by a series of eight such lesions experimentally produced in dogs. In each case a severe

FIG. 5-A

Case 3. Reduction accepted as satisfactory by attending surgeon.

FIG. 5-B

Case 3. Six months later there was complete subluxation.

FIG. 5-C

Case 3. Five years later the hip was stiff and painful.

FIG. 5-D

Case 3. Roentgenogram shows the result after fusion.

Comment: Posterior dislocation and sprain fracture of the head, with a large acetabular lip fragment which was not replaced.

Operative Findings: Complete posterior dislocation was found. The acetabulum was open posteriorly; the lip fragment was united to the ilium above the acetabulum; and there was complete disintegration of the joint. The head was fused to the ilium in subluxated position.

degree of degenerative arthritis developed within a few weeks' time. (See Figs. 1-A, 1-B, 1-C, 1-D, 2-A, 2-B, and 2-C.) This same degenerative reaction has been observed in a number of patients, due to either incomplete reduction, or gradual redislocation on weight-bearing. Roentgenograms of three illustrative cases are shown (Cases 1, 2, and 3).

It is not the authors' purpose to deal at great length with the treatment of the average case of fracture-dislocation of the hip. In brief, they believe that many cases can be reduced by manipulation, and that the lip fragment will come down with the head, falling naturally into its normal

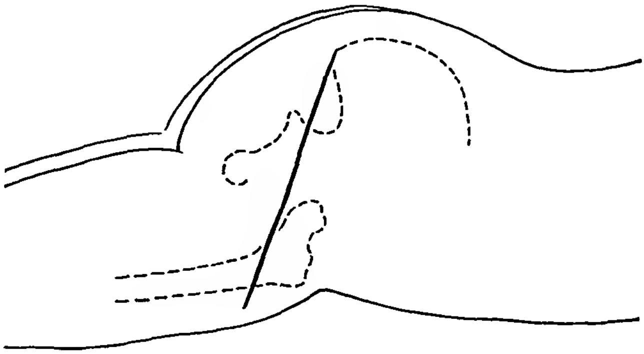

Fig. 6-A

Patient is placed prone upon the table, and the incision is made from the posterior superior iliac spine to the base of the trochanter of the right hip.

Fig 6-B

Gluteus maximus muscle is split and retracted (*A*, *A*)
Hemostats are placed under the common tendon of the piriformis (*C*) and obturator internus and gemelli (*D*).
S = Posterior superior iliac spine; *F* = Sciatic nerve; *E* = Quadratus femoris muscle; *T* = Trochanter.

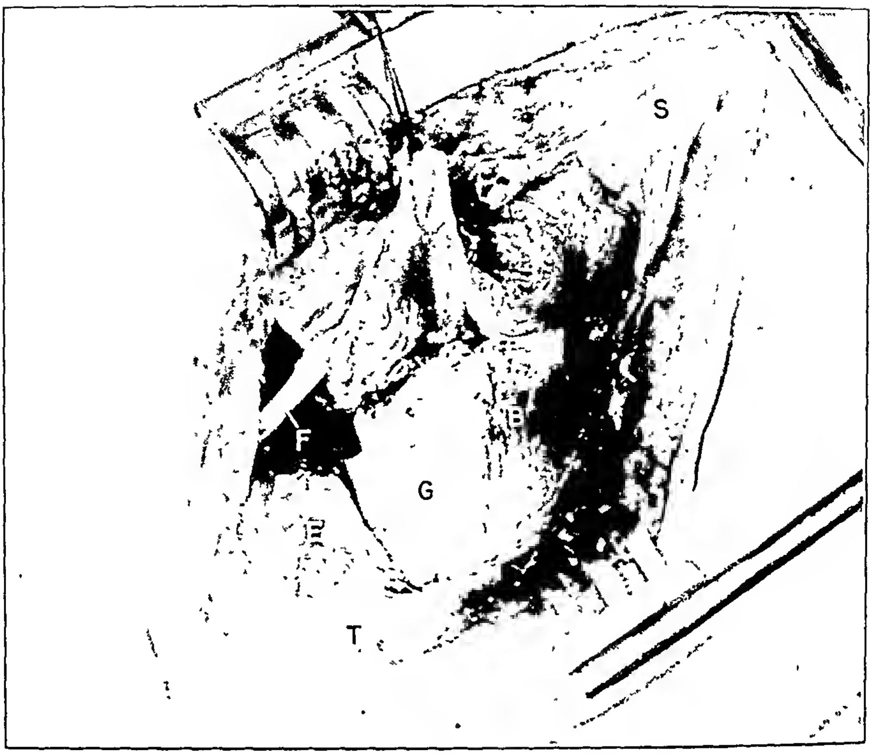

Fig. 6-C

The tendon of the piriformis, obturator, and gemelli is divided, and the muscle bellies (*C* and *D*) are retracted medially, exposing the posterior wall of the acetabulum (*G*). The sciatic nerve (*F*) is protected at its exit from the notch by the muscle bellies.

B = Gluteus minimus; *E* = Quadratus femoris; *T* = Trochanter.

position as the head reenters the acetabulum. If the lip fragment is small and narrow, it probably does not matter whether it comes completely down or not, as little if any of the articular surface is involved. Hip-spica immobilization in abduction and external rotation for eight to ten weeks, with two more weeks in bed for exercises, will be adequate for strong osseous union.

However, in many instances inadequate reduction of the head, of the lip fragment, or both, has been allowed to persist, thus establishing a perfect set-up for the development of degenerative arthritis. This may be due to failure to recognize in the postmanipulative roentgenogram, a small persistent subluxation, or unfamiliarity with the surgical technique of open reduction.

In this group there are many patients in whom, by operation, perfect anatomical reposition can be established. The technique for this procedure has been described accurately in the literature only once, by Griswold and Herd in 1929. Osborne, in 1930, described a posterior approach to the retrocotyloid region, but never utilized it.

The authors wish, therefore, to describe the technique which in their experience has been the simplest, surest, and safest for this acetabular redintegration.

FIG 6-D

Ribbon retractor (*J*) is placed in the pelvis against the intrapelvic surface of the acetabular floor The posterior lip fragment (*H*) is in its characteristic position

L=Head of the femur, *K*=Silk thread placed through the capsule

FIG 6-E

Lip fragment (*H*) is replaced.

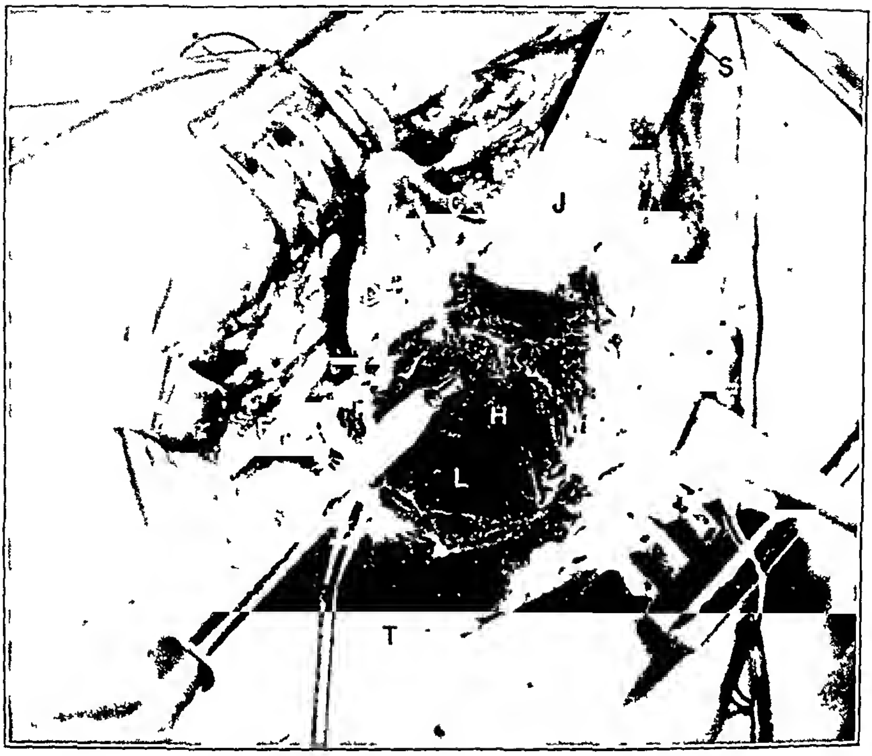

Fig. 6-F
Screw being inserted obliquely through the fracture line.

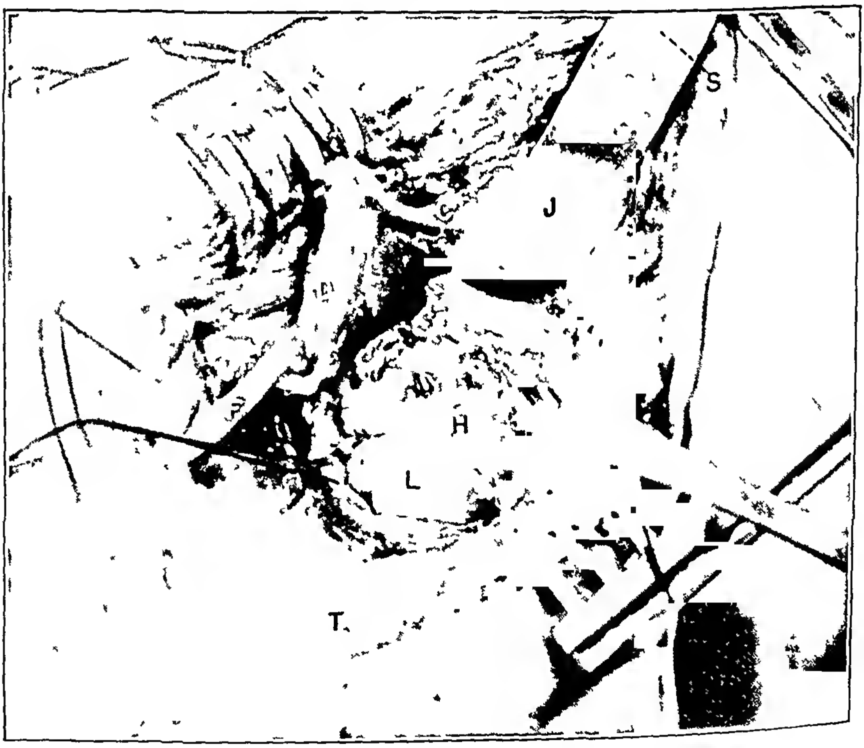

Fig. 6-G
In final position, screw is tight, and fracture line is obliterated

THE OPERATIVE TECHNIQUE

The patient is placed prone and close to the edge of the table so that the extremity can be flexed over it if desired. The incision (Fig. 6-A) extends from the posterior superior iliac spine outward and downward to the base of the greater trochanter, and is deepened to the fibers of the gluteus maximus muscle. At its outer end the aponeurosis of this muscle is exposed and divided, thus opening the peritrochanteric bursa. A finger can now be placed inward and upward under the gluteus maximus muscle, which is divided the full length of the incision (Fig. 6-B). Very little bleeding is encountered, as the branches of the superior gluteal artery are contained in the superior half of the muscle and the inferior gluteal tributaries are in the inferior half. The two halves of the gluteus maximus muscle are retracted from each other. This gives a complete exposure of the sciatic nerve, the gluteus medius, piriformis, obturator internus, gemelli, and the superior border of the quadratus femoris muscles. The interval between the superior border of the piriformis and the inferior border of the gluteus medius is located, and the tip of a curved hemostat inserted from above downward under the common tendon of the piriformis, obturator internus, and gemelli. Another hemostat is inserted under this tendon from below, passing between the superior border of the quadratus femoris and the inferior border of the gemelli (Fig. 6-B). The tendon is now divided (Fig. 6-C), and, by retracting the muscle bellies medialward, an excellent exposure of the posterior wall of the acetabulum is secured. The trunk of the sciatic nerve is well protected by these muscle bellies which fold over it much as a closed book enfolds a book mark. A long, narrow, ribbon retractor is placed in the pelvis between

FIG. 7-A

Case 4. After manipulation the head is in satisfactory position in the acetabulum, but the lip fragment is not replaced. On allowing the extremity to approach a neutral position, the head dropped out of the acetabulum.

FIG. 7-B

Three years after fixation of the lip fragment with a beef-bone screw.

FIG. 8-A

Case 5. Posterior dislocation of right hip with lip fragment in acetabulum.

FIG. 8-B

After manipulation the head is opposite, but not in the acetabulum.

FIG. 8-C

Posterior view five years after operative removal of the fragment and reduction of the dislocation; function was normal.

the greater sciatic notch and the ischial spine, and against the intrapelvic surface of the acetabular floor (Fig. 6-D). Further exposure, if needed, is easily secured by subperiosteal elevation of the gluteus minimus superiorly.

From this point the operative technique will naturally depend on the pathology present. In the average case the dislocation has already been reduced, and it is only necessary to derotate the lip fragment (Fig. 6-E), place it in perfect anatomical position, and affix it with Matthews wires, nails, beef-bone, or vitallium screw (Fig. 6-F). Due to the thickness of the ilium at this point, there is plenty of bone in which the screw can get a good purchase. The screw must be placed at an oblique angle upward, however (roughly toward the middle of the iliac crest), so as to avoid penetrating the articular cartilage.

Postoperatively traction, hip spica cast, or Wilkie boots have been used. Active exercise is allowed in from eight to ten weeks, depending somewhat on the size of the lip fragment. In those cases with accompanying sprain fracture of the head, full immobilization is maintained for at least eight weeks. Weight-bearing is permitted in from ten to twelve weeks.

INDICATIONS FOR OPEN REDUCTION

Indications for open reduction are illustrated by the following cases:

1. Large lip fragment remains displaced after manipulative reduction of femoral head (unstable reduction).

CASE 4 (Figs. 7-A and 7-B). A. de C., aged forty-five, was injured in an auto accident. The hip was easily reduced, but the head remained in the acetabulum only when abducted

FIG. 9-A

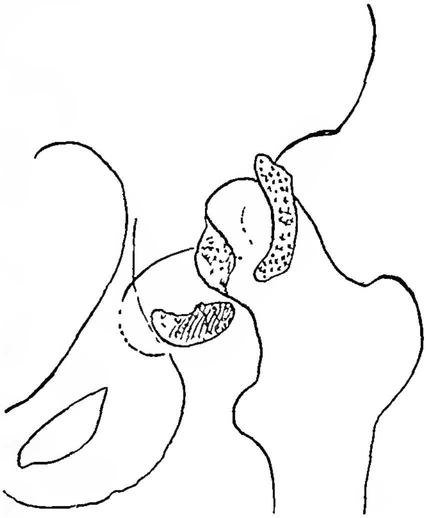

FIG. 9-B

Case 6. Roentgenogram and diagram of roentgenogram show posterior dislocation, lip fragment, and sprain fracture of the head

FIG 9-C

After manipulation head was not properly placed in the depth of the acetabulum, and the lip fragment was not replaced.

FIG. 9-D

Fig. 9-D: Postoperative roentgenogram taken following excision of the head fragment, and reduction and fixation of the lip fragment with vitallium screw.

Fig. 10-A

Case 7. Roentgenogram of the left hip taken after manipulation shows the head in the acetabulum, fracture through the floor of the acetabulum, and large lip fragment not replaced.

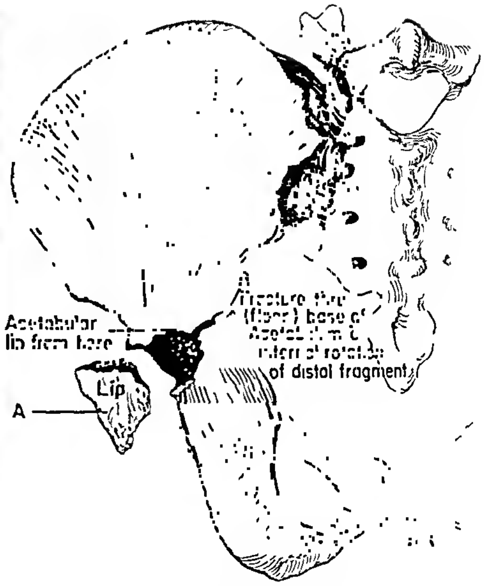

Fig. 10-B

Condition disclosed at operation (posterior view). *A:* Lip fragment; *B:* Fracture through the floor of the acetabulum. Note internal-rotation displacement of the distal fragment.

Fig. 10-C

Roentgenogram shows the postoperative result.

45 degrees and externally rotated. When the thigh was allowed to come to a neutral position the head dropped out of the acetabulum. A large fragment of the posterior lip remained displaced. At operation the lip fragment was found to be much larger than the roentgenogram would indicate, consisting of over one-half of the posterior lip. Without operative reduction of this fragment, progressive subluxation would surely have occurred on weight-bearing, followed by arthritic disintegration.

2. The lip fragment is in the acetabulum.

Case 5 (Figs. 8-A, 8-B, and 8-C). L. W., aged twenty-six, was injured in an auto accident. The hip was manipulated, but reduction of the dislocation was impossible because the lip fragment was displaced into the acetabulum. At operation the fragment was found to be a very thin edge of acetabular lip. Reduction was completely stable, and the fragment was removed.

3. Sprain fracture of head prevents reduction.

Case 6 (Figs. 9-A, 9-B, 9-C, and 9-D). C. W., aged forty-five, was injured in an auto accident. Repeated manipulations failed to place the head snugly in the acetabulum. Preoperative roentgenograms disclosed, in addition to the lip fragment, a sizable fragment deep in the acetabulum, obviously attached to the round ligament, and a corresponding defect in the inferior surface of the head of the femur. At operation the head was redislocated from the acetabulum. The mass of cancellous bone attached to the

round ligament was obviously not fitting snugly into its bed in the femoral head. It was removed, and no further difficulty was encountered in reducing the head and lip fragment.

4. Fracture through the floor of the acetabulum allows rotation of distal half of innominate bone, preventing reduction.

CASE 7 (Figs. 10-A, 10-B, and 10-C). G. W. was injured in an auto accident, and had a posterior dislocation, posterior lip fracture, and transverse fracture through the floor of the acetabulum. The posterior lip fragment remained high. At operation it was found that the lip fragment would not fit accurately into the defect.

The head was redislocated, and, with the extremity externally rotated and adducted, and the posterior acetabular lip out of the way, a perfect view of the entire acetabulum was obtained. It was then obvious that the distal fragment had rotated inward about two millimeters, making a definite "jog" in the articular surface which prevented anatomical reduction of the head and lip fragment. The tip of a screw driver was inserted into the fracture line, and by prying, the superior end of the distal fragment snapped into position. The femoral head was reduced, anatomical reposition of the lip fragment secured, and fixation accomplished by using two vitallium screws, one passing through the lip fragment into the superior fragment of the innominate bone, and the other through the lip fragment into the distal fragment of the innominate bone.

(In a second case in which this happened, reduction of the inward rotation of the distal half of the innominate bone was secured without redislocating the femoral head. In neither of these cases was the displacement of the distal fragment visible in the roentgenograms.)

5. An associated fracture of the femoral shaft prevents control of the head.

One case has been treated and two others have been observed, in which there was a fracture of the femoral shaft, accompanying the fracture-dislocation of the hip. In two of these cases satisfactory reduction was accomplished by the insertion of a Steinmann pin through the trochanteric region. In the third case satisfactory control of the proximal fragment was secured through the use of the pin, but operation was necessary because the lip fragment was displaced into the acetabulum.

SUMMARY

A review of the literature shows that posterior dislocation of the hip with associated fracture of the acetabular lip is comparatively uncommon.

It is characteristically an "automobile injury" and hence is increasing in frequency.

Without perfect reduction, arthritic disintegration of the joint occurs rapidly, due to mechanical incongruity of joint surfaces.

Roentgenograms of good quality must be studied with great care before the "reduction" is accepted.

Open reduction is indicated when:

1. *The lip fragment is large and does not come down into position* when the head is reduced (unstable reduction).
2. The lip fragment is in the acetabulum.
3. Sprain fracture of the head prevents perfect reduction.

4. A fracture through the acetabular floor allows rotation of the distal fragment which prevents reduction.

5. Femoral shaft fracture prevents control of the head.

The author has obtained satisfactory reduction by this operation.

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ADDUCTION TRACTION IN TROCHANTERIC FRACTURES

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The accepted management of treating fractures about the hip joint, other than fractures of the neck of the femur, has followed the rule of approximating the distal fragment to the uncontrollable proximal fragment, with the thigh in abduction and flexion. The authors have recently discarded this practice for what they consider a better method.

Over a period of ten years, about 1,500 intertrochanteric fractures were treated on the Fracture Service by traction in a Thomas splint suspended in a Balkan frame, with the thigh flexed and abducted. For years the results were accepted as satisfactory. Although shortening and coxa vara deformity were frequent, only one non-union, in a pathological fracture, was observed.

The disadvantages of traction methods are minor when compared to the hazards of spica plaster casts which often result in high mortality and poor maintenance of reduction.

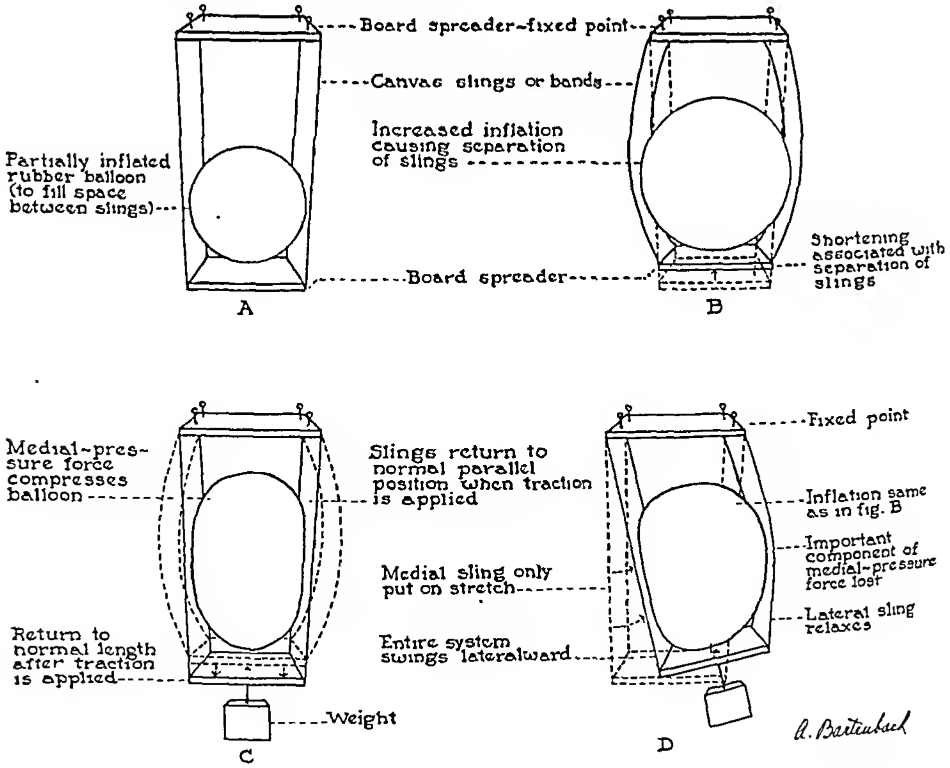

FIG. 1

Mechanical principles involved in treating intertrochanteric, pertrochanteric, and subtrochanteric fractures in adduction instead of abduction traction.

Some have advocated the flanged nail in trochanteric fractures, which often splits the bone; but even if this fails to occur, the method does not permit the patient to be up any sooner than the eight weeks required for closed traction[2].

Seeking improvement in the reduction of these fractures, the authors have applied the method of longitudinal parallel ligament and muscle pull, as used in the reduction of Pott's fracture with separation of the tibiofibular articulation[1].

The new method applies a physical law. When two parallel bands lose their parallel position, equal force applied in their longitudinal axis realigns the bands (Figs. 1*A*, 1*B*, and 1*C*).

If, for example, a partially inflated rubber balloon is placed between these parallel bands (Fig. 1*A*), they remain parallel, but, if the balloon is still further inflated, the bands lose their parallel position (Fig. 1*B*). However, traction in the longitudinal axis tends to parallel the bands, and a lateral force compresses this ball with a force equal (approximately) to the traction force (Fig. 1*C*). If the lower board spreader is moved lateralward and tilted, as would occur in abduction of the leg, one sling is relaxed (Fig. 1*D*), and, when traction is applied, the effect of the medial pressure force is lost for the most part on the lateral side. Here, and in Figure 2*D*, the pelvic tilt is omitted for the sake of clarity.

The coxa vara deformity in hip fractures is the inflated space, as in

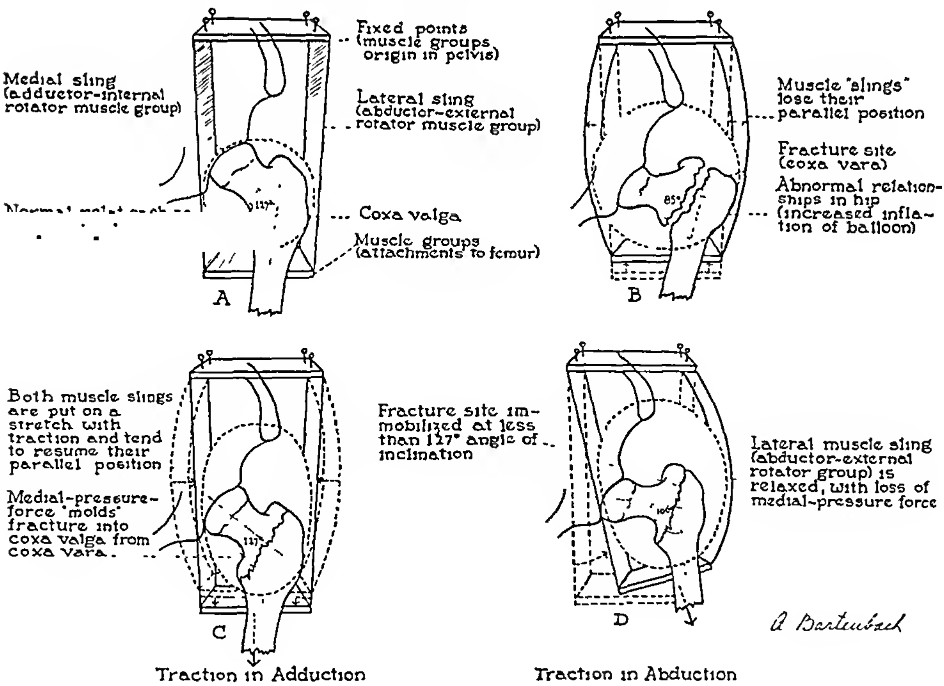

FIG. 2

Mechanical principles applied to specific fracture,—that is, the analogous situation as applied to the anatomy of the hip. In *D* the pelvic tilt has been omitted to show the mechanical principle more clearly.

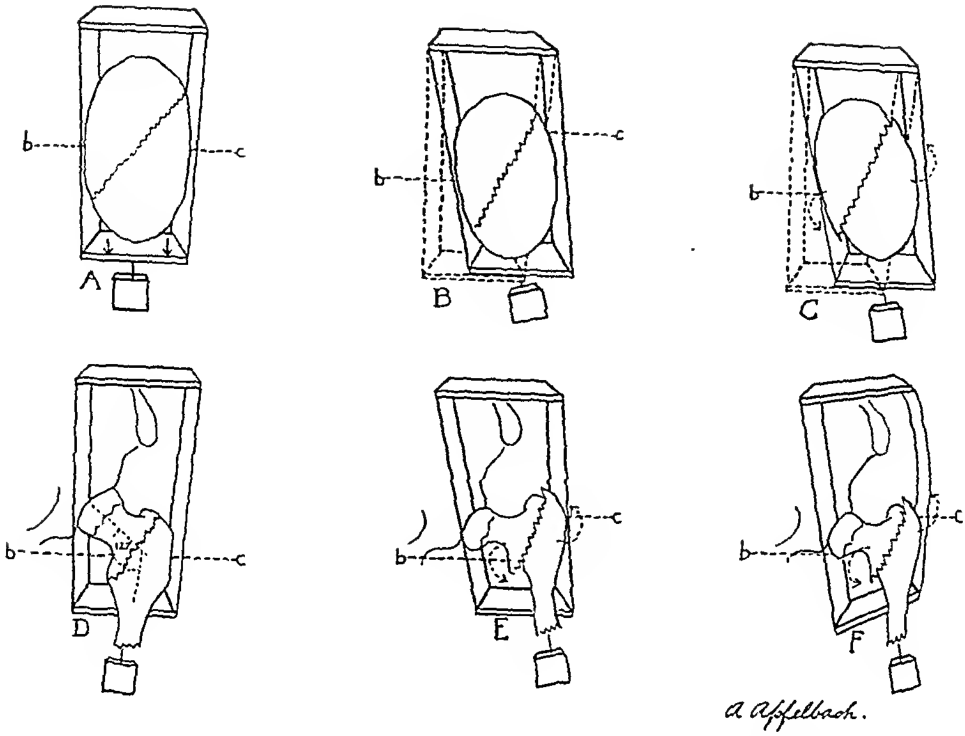

FIG. 3

Mechanical principles of circular-friction rotation applied to the treatment of intertrochanteric, pertrochanteric, and subtrochanteric fractures in abduction traction.

the balloon. If traction is applied equally to the adductors and abductors with the leg in adduction, the parallel force molds the fracture into a coxa valga position, while the traction restores the length of the limb (Fig. 2*C*).

In abduction traction the pelvis does not remain a fixed point, but tilts upward because the limbs of the patient tend to parallelism. Therefore, in many intertrochanteric fractures parallel ligament and muscle pull is obtained in abduction, so that good reduction may result. The authors have observed, however, that the pelvis does not always tilt in proportion to the abduction of the thigh, so that abduction with parallel ligament and muscle pull is not fully attained.

Another disadvantageous force, in abduction traction, is that of circular-friction rotation.

If an egg-shaped solid, cut obliquely in halves, is substituted for a balloon in the rectangular parallelogram, the pressure produced by the bands at points *b* and *c* is equal and at the same level, and there is no friction rotation (Fig. 3*A*); however, if, in the lateral swing, the parallelogram is maintained, the pressure by the bands will be equal on both sides of the solid, but at different levels (Fig. 3*B*), so that the circular friction force will move one half upward and the other half downward (Fig. 3*C*). In adduction traction in an intertrochanteric fracture, pressure at *b* and *c* neutralizes friction rotation because the pressure occurs at equal levels (Fig. 3*D*), and hence no displacement will occur.

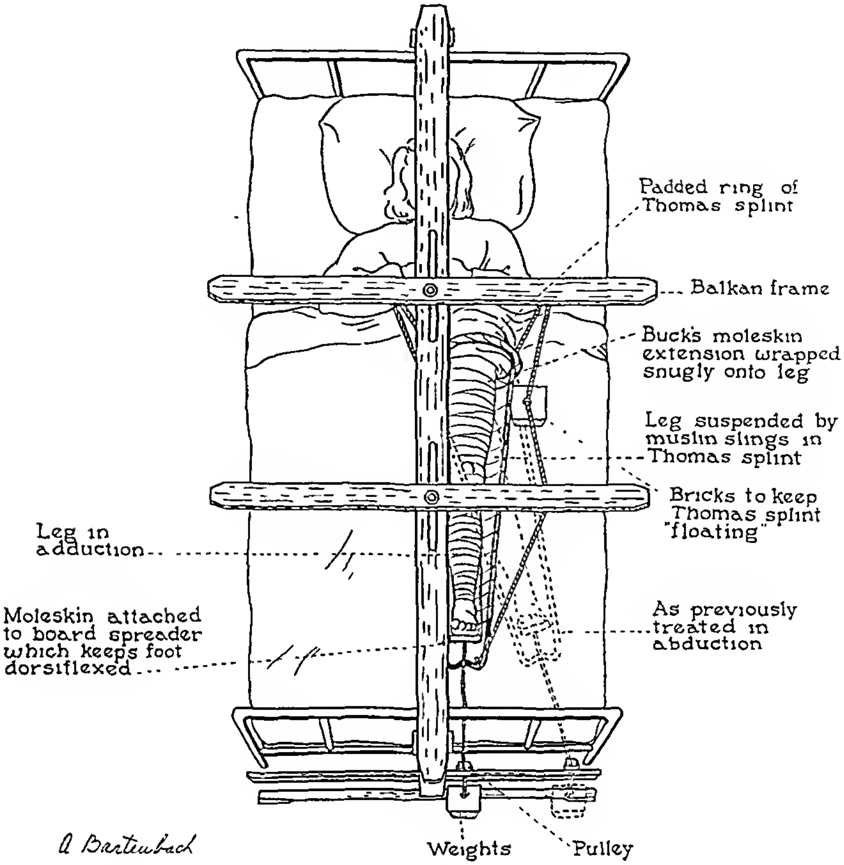

Fig. 4

The method used in applying the principle of traction in adduction, instead of abduction.

By substituting for the ovate solid the fractured trochanter in abduction traction (Fig. 3*E*), coxa vara deformity will be produced by circular friction rotation. A parallelogram such as is shown in Figure 3*E* can occur only when the pelvis does not tilt with abduction. Since this seldom occurs, coxa vara deformity is caused by laxity of the lateral ligaments and muscles, and by circular-friction rotation (Fig. 3*F*). In other words, coxa vara deformity may be caused by laxity of the lateral ligaments, by circular-friction rotation, or by both forces acting together. Therefore, to avoid failure in the extension of intertrochanteric fractures, the leg should never be abducted, but should be placed in adduction.

Observations were made on eighty-five cases of intertrochanteric, subtrochanteric, and pertrochanteric fractures. In seventy of these, traction in adduction was employed. In fifteen, equal weights were used, but the thigh was flexed and abducted. In none of the controls was the reduction as perfect nor the angle as ideal as by the newer method. In adduction the fractures healed consistently in coxa valga.

On admission to the ward, patients with hip injuries are immedi-

Fig 5-A

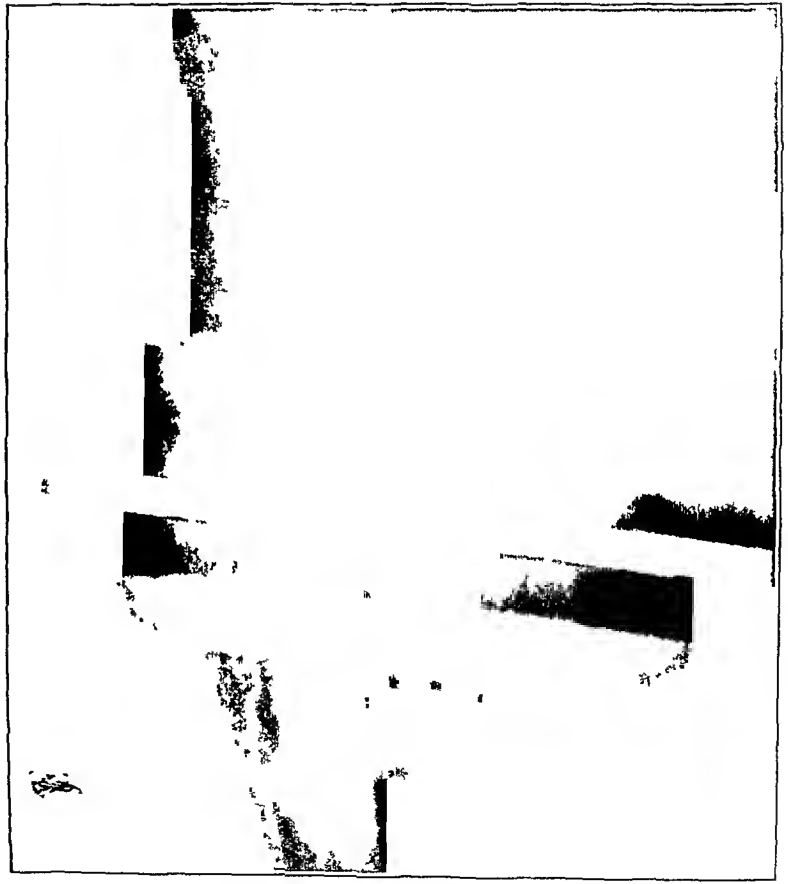

Fig 5-B

Case 1 Patient, female, aged sixty-two, fell on icy sidewalk, and was put in adduction traction After nine weeks of traction, there was union in coxa valga

Fig 5-A: Fracture before traction was begun

Fig 5-B Five days after traction in adduction, 135 degrees of coxa valga had been obtained

Fig. 6-A

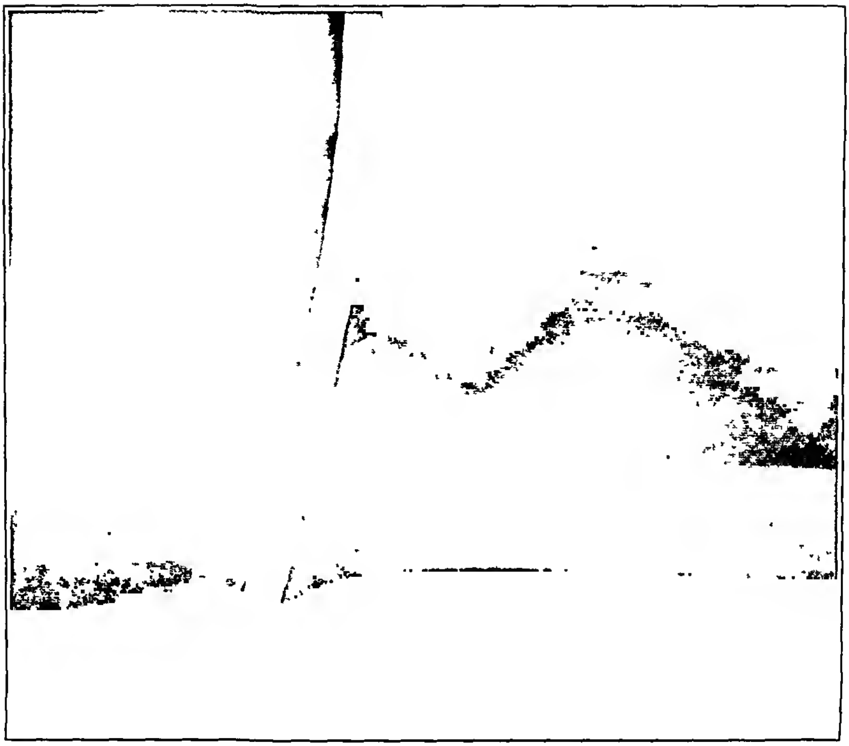

Fig. 6-B

Case 2. Patient, female, aged sixty-nine, slipped on icy pavement, fell on hip, and was placed in adduction traction three hours later.
Fig. 6-A: Shows coxa vara deformity.
Fig. 6-B: After traction of thirty-five pounds for four days, reduction in coxa valga of 170 degrees was obtained.

Fig. 7-A

Fig. 7-B

Case 3. Patient, female, aged seventy-five, slipped and fell on an icy sidewalk, and was taken to the hospital within six hours.
Fig. 7-A: Intertrochanteric fracture with coxa vara of 100 degrees.
Fig. 7-B: Four days after traction in adduction of thirty-five pounds, there was coxa valga of 140 degrees.

Fig. 8-A

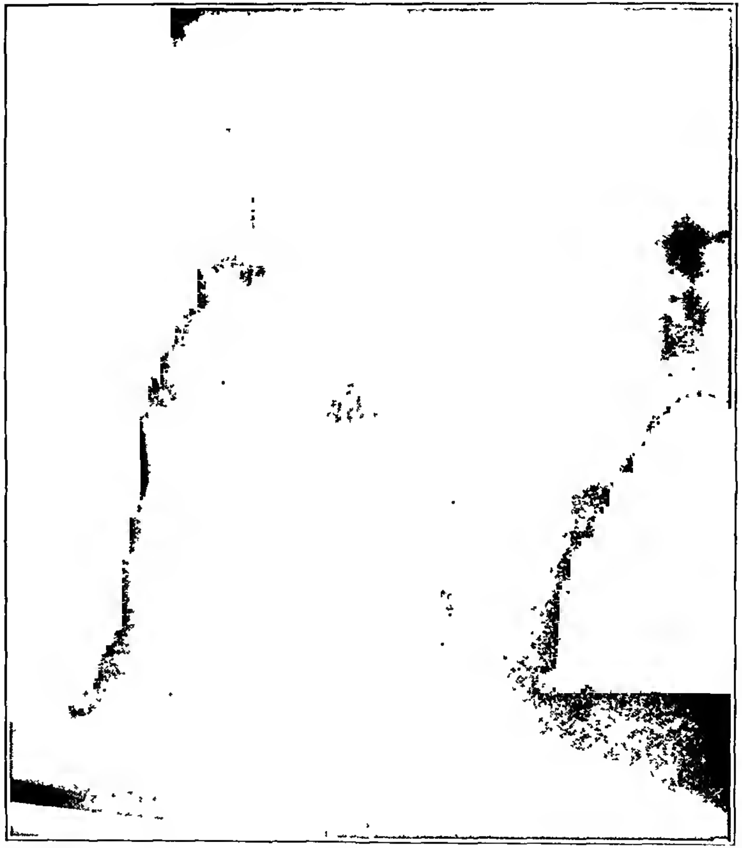

Fig. 8-B

Case 4. Patient, female, aged fifty-eight, fell in kitchen, and was taken to the hospital four hours later.
Fig. 8-A: Intertrochanteric fracture with coxa vara of 90 degrees.
Fig. 8-B: After one week in adduction traction, there was coxa valga of 130 degrees.

that attention became focused upon tibial torsion as a factor in recurrence of the deformity. The author was seeking the reason behind the recurrence of the adduction deformity in only one foot, although both feet had been thoroughly corrected and checked by roentgenograms. In a previous paper [4] it was noted that adduction was the chief deformity recurring in those feet which relapse, and closer observation has now revealed that in over 90 per cent. of these cases tibial torsion was present in the leg which showed recurrence and absent in the other which had maintained its correction.

ANATOMY

Before the equinovarus deformity has been corrected it is often difficult to determine whether internal rotation of the tibia is present, or if present, to what degree. However, after the equinovarus has been corrected and the child is walking, it is easy to detect tibial torsion, since the child invariably "toes in" on the affected side. A line dropped from the anterior superior spine of the ilium, bisecting the patella, will fall to the lateral border of the foot outside the little toe, instead of between the great and second toes as is normal. With the patella pointing straight forward, palpation of the malleoli at the ankle will show the external malleolus to be anterior to the medial malleolus instead of parallel to it as is normal. Thus, when the child is walking, the weight-bearing thrust falls obliquely across the long axis of the foot and drives the scaphoid around to the medial side of the head of the talus with re-creation of the adduction deformity of the forefoot. If this same vicious force is allowed to continue, varus of the heel and inversion of the foot will follow the adduction deformity. These undesirable sequelae to correction of club-foot can be obviated if a rotation osteotomy of the tibia is done when tibial torsion is present.

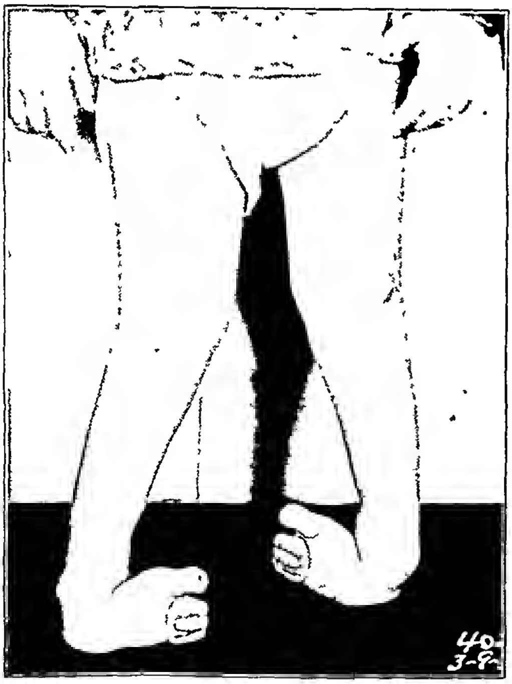

FIG. 2-A

Case 1. Severe bilateral congenital equinovarus in a patient, three years of age, who had had no previous treatment.

INDICATION FOR CORRECTION

One hesitates to draw a hard and fast limit to the degree of deformity which requires attention, since correction means an open operation on a young child. The author feels, however, that no tibial torsion of 15 degrees or more should be disregarded, and in this series all

patients operated on had a deformity of 20 degrees or more. There is an advantage in derotating the tibia as soon as the foot is corrected, because the child is already accustomed to the plaster casts. Occasionally a trial in weight-bearing may become necessary to convince the parents that the deformity will most surely recur. In this series those children with tibial torsion who were allowed to walk before this was corrected relapsed into adduction within from five to twelve months.

OPERATIONS

Some authors advocate the application of long leg casts with the knees held at right angles while correcting the equinovarus, adding an external twist to the long axis of the lower leg in an attempt to correct the internal tibial torsion, but any force aimed at correcting tibial torsion by this method is lost in the knee joint, and instead of correcting the deformity may produce an undesired laxity in the structures within and around the knee joint. There are described in the literature at least three operations for derotating the tibia, and a short résumé of each will indicate the author's preference for one type.

A. *Transverse Osteotomy*

This is the simplest and probably the oldest operation for this type of deformity. A transverse cut through the tibia is made about one inch

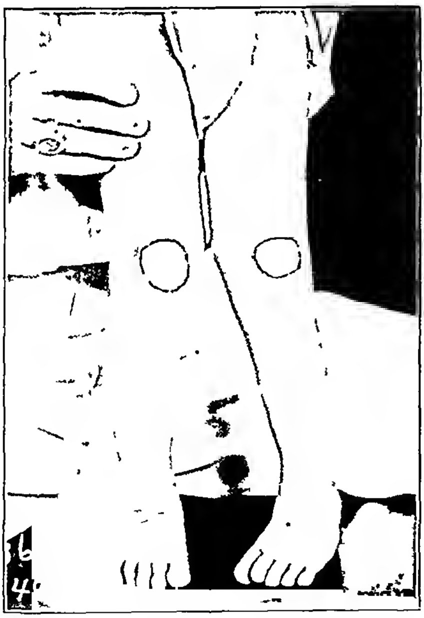

FIG. 2-B

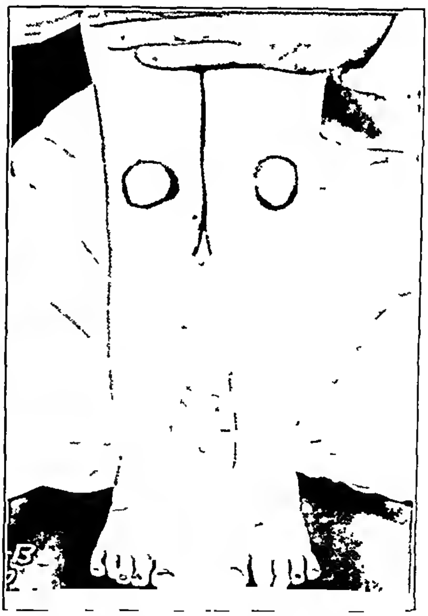

FIG. 2-C

Fig. 2-B: Case 1. One year later, the feet have been corrected by the conservative multiple-cast method. Patellae are marked to show the inward torsion in the long axis of the left tibia.

Fig. 2-C: Case 1. Three months later than Fig. 2-B, following controlled rotation osteotomy of the left tibia. Note proper alignment between knee and foot.

below the proximal epiphyseal plate, and the distal fragment is rotated externally on the proximal fragment. This operation is unsatisfactory principally for three reasons:

1. Some of the correction takes place in the knee joint since the upper fragment also rotates externally.
2. Fixation depends upon the plaster cast.
3. Angulation may take place at the level of the osteotomy. (Three cases of genu valgum have been seen following transverse osteotomy for tibial torsion.)

B. *Longitudinal Osteotomy*

This is an operation described by Haas, wherein multiple longitudinal incisions are made in the upper end of the tibia parallel to its long axis and separated from each other by narrow strips of cortex. This operation is an improvement over the transverse osteotomy because angulation at the operative site is prevented, but loss of correction can still take place in the knee joint and fixation depends upon the external plaster cast.

C. *Controlled Rotation Osteotomy*

This is an operation devised by O'Donoghue and is preferred by this author because it is technically foolproof. The plan of operation is a Z osteotomy in a circular tube of bone, with removal of a strip of cortex to allow rotation. A longitudinal saw cut is made through the anterior cortex of the upper one third of the tibia, about two inches in length and parallel to the crest. The two horizontal cuts (the arms of the Z) are next made, one at each end of the longitudinal cut. The distal horizontal cut is made in the same direction as that of the desired correction, that is, outward or to the lateral border of the tibia; the proximal cross cut is exactly opposite or towards the medial border of the tibia. The linear section of the posterior cortex is completed by driving an osteotome through the long longitudinal saw cut. The tibia has then been divided into two long opposed fragments still hinged together on the posterior surface by a small portion of the posterior cortex. A longitudinal strip of cortex is removed by making a second longitudinal cut parallel to the first, the width of the strip being predetermined by the amount of rotation desired. With the edges of the longitudinal cut placed in approximation, one can determine how much

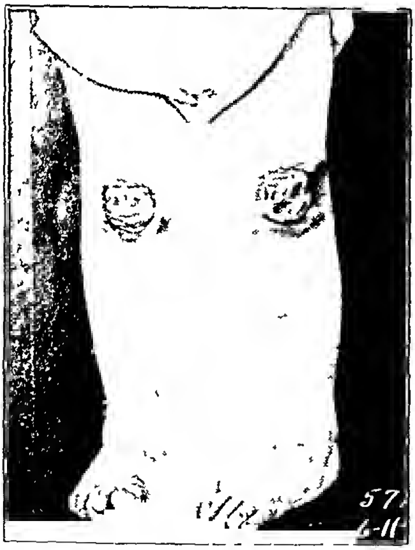

Fig. 3-A

Case 2. Bilateral congenital equinovarus corrected by the conservative multiple cast method. Note the marked internal torsion of the left tibia with malalignment of the foot and knee.

correction has been obtained, and more can be secured if necessary. Finally the edges of the longitudinal cut are held in approximation by sutures placed through opposing drill holes at each end of the longitudinal cut. This operation has the following advantages over the other types of osteotomy:

1. The amount of rotation desired is gained in the tibia and nothing is lost in the knee joint.

2. The fragments are fixed internally, reducing to a minimum the chances for postoperative distortion.

3. The cast serves only to protect the leg, and is not utilized to obtain or maintain correction.

4. There is a large surface for callus which affords quick healing.

Fig. 3-B

Case 2. Showing the immediate position after rotation osteotomy. The plaster cast has been cut over the dorsum of the foot to allow stretching of the heel cord during the convalescent period.

The illustrations used in this article are photographs of two typical cases chosen from among the sixty-two which constitute the basis for this report.

SUMMARY

1. Internal tibial torsion accompanies club-foot in a fair percentage of cases (17 per cent. in this series).
2. It is a major factor in recurrence of the club-foot deformity.
3. Tibial torsion of 15 degrees or more should be treated surgically after the equinovarus deformity has been corrected.

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EXAMINATION OF THE SHOULDER FOR CALCIUM DEPOSITS

Technique of Fluoroscopy and Spot-Film Roentgenography

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Not infrequently calcium deposits in the region of the shoulder joint are discovered accidentally in roentgenograms of the chest or upper extremity. Usually the patient is unaware of the presence of the calcium; the physician regards it as merely an incidental finding of no clinical significance, and nothing further is done about it. Lately, however, more interest has been shown in these deposits, and their importance as a potential source of pain and disability is now generally recognized [2, 3, 4, 6, 10, 11].

Although various roentgenographic techniques in the examination of the shoulder for calcium deposits have been recommended [1, 7, 8], no one has stressed the importance of fluoroscopy as a preliminary procedure for the detection of calcium, or advocated the combination of spot-film roentgenography with fluoroscopy as the best means of recording the precise location of such deposits. Elsewhere [2] are presented the results of a three-year survey of over 6000 supposedly normal individuals whose shoulders were fluoroscoped for calcium deposits, most of them several times, at intervals of a year or less.

In a study of this nature, fluoroscopy was found to be preferable to roentgenography alone for several reasons. Deposits may be overlooked in a roentgenogram when they are superimposed upon the head of the humerus or the overlying acromion (Figs. 1-A, 1-B, 1-C, 1-D, 1-E, 4-A, 4-B, and 4-C). The density of the shadow cast by deposits on the roentgenogram varies greatly. The calcium is usually spread out in a thin layer which casts little shadow unless it is so placed between tube and film that the roentgen rays have to traverse the length or breadth rather than the thickness of the deposit (Figs. 4-A, 4-B, and 4-C). If examination is restricted to roentgenography, many roentgenograms should be taken of each shoulder in different planes and with varying degrees of humeral rotation. Even then calcium collections, which would be seen on fluoroscopy, may be missed entirely. The expense of such an examination and its inherent element of error are self-evident.

Fluoroscopy, properly performed, makes visible very nearly the full extent of the shoulder-joint capsule within the space of a few moments. It is effective, speedy, and relatively inexpensive. It is as useful in inspecting the shoulder as it is in the examination of the gastro-intestinal tract. Due to its simplicity of application and low cost, it furnishes an ideal means not only for detecting the presence and position of calcium deposits, but for following their course from month to month or year to

Fig. 1-A

Fig. 1-B

Fig. 1-C

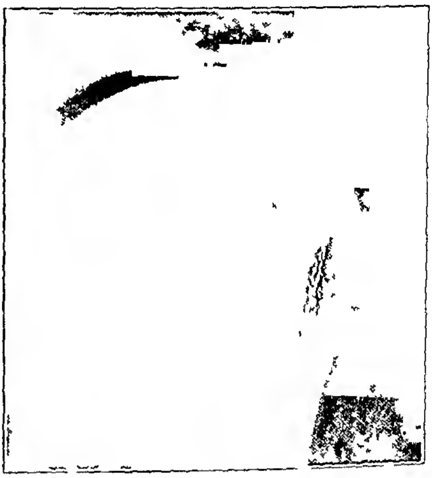

Fig. 1-D

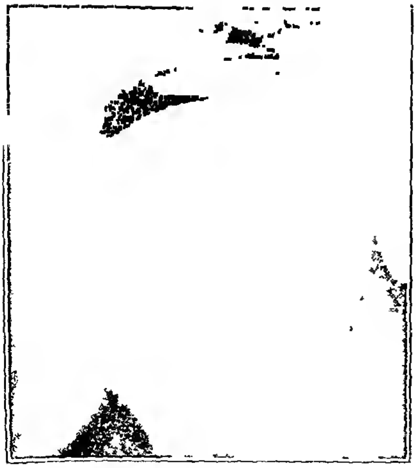

Fig. 1-E

Case 1. C. H., aged thirty-two, female, clerk. Multiple calcium deposits were detected by fluoroscopy and photographed by spot-film technique.

Fig. 1-A: Right shoulder, external rotation. Only one small deposit may be seen in the supraspinatus.

Fig. 1-B: Right shoulder, mid-rotation. The deposit seen in Fig. 1-A is now hidden by the humeral head and another small deposit, in the infraspinatus, comes into view.

Fig. 1-C: Left shoulder, external rotation. A small deposit is visible in the supraspinatus and there is the suggestion of another deposit superimposed on the head of the humerus.

Fig. 1-D: Left shoulder, mid-rotation. The supraspinatus deposit has disappeared from view and an infraspinatus deposit, a suggestion of which is seen in Fig. 1-C, has now come around into profile.

Fig. 1-E: Left shoulder, internal rotation. Neither of the deposits shown in Figs. 1-C and 1-D is longer visible, but an unsuspected little deposit in the teres minor has been brought into view.

FIG. 2-A FIG 2-B FIG. 2-C

Case 2. J. F., aged thirty-five, female, typist. Spot-film technique reveals the gradual absorption and disappearance of a large deposit. There is no hit-or-miss in this method. The site of the deposit may easily be shown in profile at each successive examination.

Fig. 2-A: December 27, 1938. Large calcium deposit in the supraspinatus portion of the short rotator cuff, left shoulder.

Fig. 2-B: January 30, 1939. The deposit is smaller; much has been absorbed.

Fig. 2-C: July 26, 1939. Just a thin line of calcium remains to mark the site of the deposit. When the arm was rotated a few degrees, this thin line disappeared completely, due to its superimposition upon the head of the humerus.

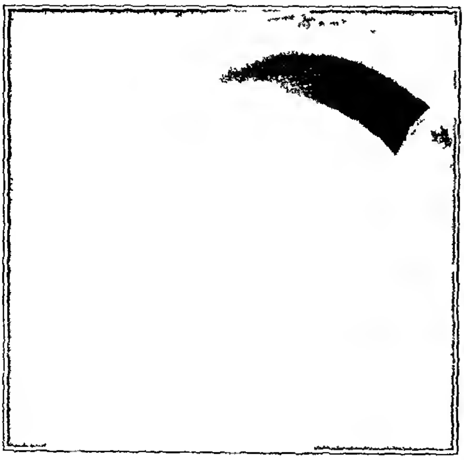

FIG. 3-A

FIG. 3-B

Case 3. J. B., aged fifty-one, male, clerk. By spot-film roentgenography calcium deposits may be photographed in the same relative position after the lapse of months or years, as shown in these roentgenograms.

Fig. 3-A: Right shoulder. A large calcium deposit which has diffused into the subacromial bursa. This is the "fluffy" type of deposit which is most apt to be absorbed.

Fig. 3-B: Right shoulder. Two months later, the deposit is nearly gone.

FIG 3-C

FIG. 3-D

Fig. 3-C: Left shoulder. A laige calcium deposit still within the substance of the tendinous short-rotator cuff. The deposit is dense and sharply outlined.

Fig. 3-D: Left shoulder. Two years later, the deposit is shown in the same degree of rotation. It has increased in size and in density.

year. In this way any increase or decrease in size may easily be checked and the effect of treatment observed (Figs. 2-A, 2-B, 2-C, 3-A, 3-B, 3-C, and 3-D). Regardless of whether or not roentgenograms are taken, fluoroscopy should never be omitted as an essential part of the examination, and both shoulders should always be inspected, since nearly 50 per cent. of those individuals with calcium in one shoulder will show it in the other shoulder as well [2]. No shoulder should ever be declared free of calcium on the basis of roentgenographic evidence alone; fluoroscopy is the final arbiter (Figs. 4-A, 4-B, and 4-C).

The fluoroscopic technique used in looking for calcium is highly

important. Each shoulder in this series was examined fluoroscopically throughout its full range of motion, with the individual standing. The author believes the erect position is an advantage, as thereby gravity, acting through the weight of the arm, tends to widen the joint space, and to prevent superimposition of the acromion on the soft tissues which are being inspected. Standing, also, is the most comfortable examining position for the patient with a painful deposit, as it helps to avoid pinching the deposit between the head of the humerus and the acromion.

Various degrees of arm rotation produce characteristic roentgenographic profiles which may easily be recognized (Figs. 1-A, 1-B, 1-C, 1-D, and 1-E). The outstanding anatomical features which serve to differentiate and identify them may be summarized as follows:

1. *External Rotation* (Figs. 1-A and 1-C)

a. The upper outer border of the humeral head has a definite protruding angle formed by the greater tuberosity.

b. A notch or sulcus above the greater tuberosity represents the site of the supraspinatus insertion.

c. The lesser tuberosity stands out in profile, parallel to and medial to the greater tuberosity.

d. The bicipital sulcus is well marked as a vertical groove between the tuberosities.

e. The medial surface of the head is a smooth hemisphere formed by the articular surface, with an indentation below it at the junction of the articular surface with the humeral shaft.

f. The greater tuberosity often has a cystic appearance, a circular area of decreased density about the size of a twenty-five-cent piece, which represents the epiphyseal outline. This has been seen in adults as well as adolescents.

2. *Mid-Rotation* (Figs. 1-B and 1-D)

a. The upper outer border of the humeral head is now a rather flat or slightly rounded oblique plane.

b. The tuberosities and bicipital sulcus are no longer clearly outlined.

c. The hemispherical articular surface remains, but its axis is tilted further upward and the indentation below it is less marked.

d. The cystlike appearance of the greater tuberosity (Figs. 5-A and 5-B), if present, becomes more distinct, due to removal of the previously interposed lesser tuberosity. The size and shape of the "cyst" remain essentially unchanged. Such "cysts" must not be confused with bone cysts, giant-cell tumors, fractures, or other pathological conditions of the proximal end of the humerus. A lack of appreciation of their true nature has been responsible for more than one needless operation [5, 9].

3. *Internal Rotation* (Fig. 1-E)

a. The rounded curve of the articular surface now occupies the outer

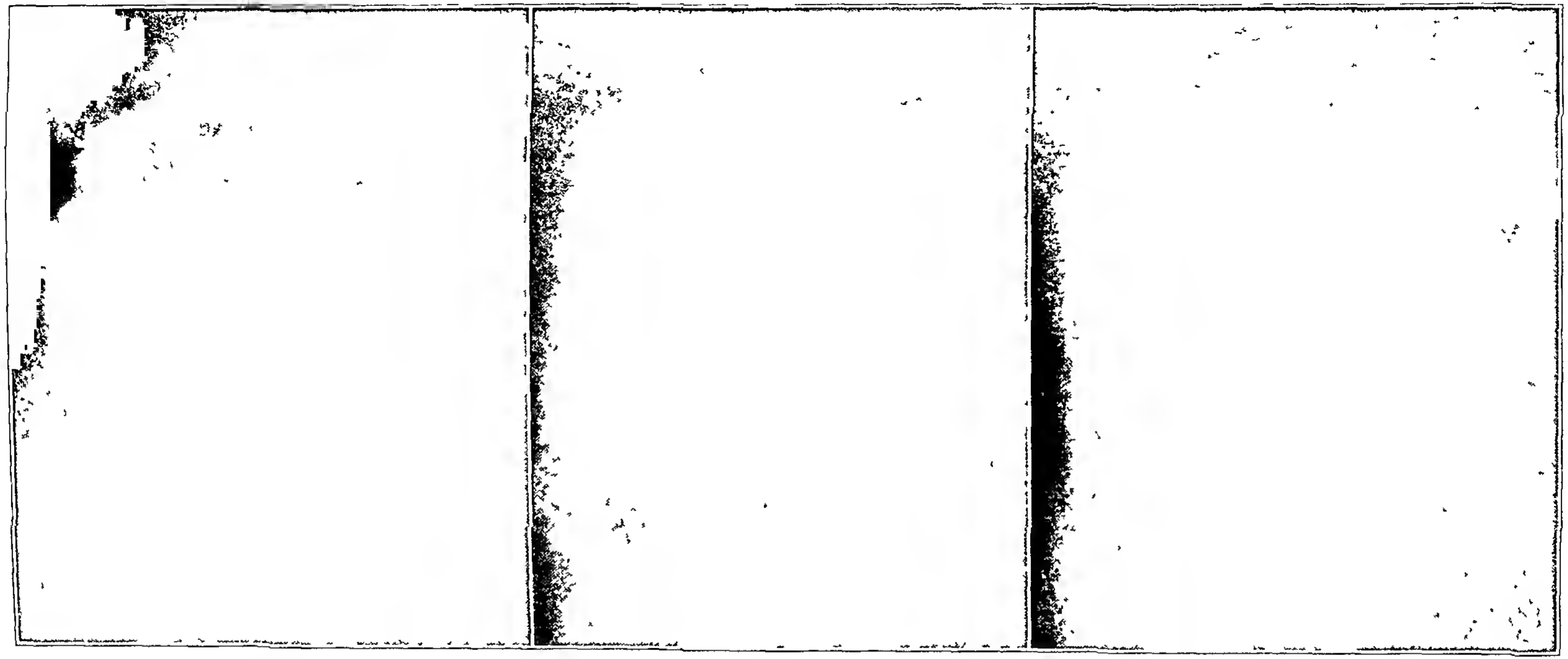

Fig. 4-A Fig. 4-B Fig. 4-C

Case 4. T. R., aged fifty-two, female, clerk. These roentgenograms, taken without fluoroscopy, show how easy it is to miss even a large deposit when roentgenographic examination alone is relied upon.

Fig. 4-A: Large deposit in supraspinatus portion of the short-rotator cuff, right shoulder.

Fig. 4-B: Two weeks later, the deposit seems to have disappeared; actually it is hidden by the superimposed humeral head and acromion process, due to rotation of the arm.

Fig. 4-C: Two months later, a roentgenogram taken with the arm in its original position shows that the deposit is still present.

Fig. 5 A

Fig. 5-B

Case 5. D. G., aged eighteen, female, clerk. Cystic appearance of the greater tuberosity of both shoulders, found upon routine fluoroscopic examination. There were no symptoms. Physical examination was negative. Nothing was found to suggest a pathological process. Apparently normal shoulders frequently present this cystic appearance upon fluoroscopy.
Fig. 5-A: Right shoulder, mid-rotation.
Fig. 5-B: Left shoulder, mid-rotation.

portion of the head, with its axis pointing up and out. The indentation beneath it appears on the outer border of the shaft.

b. The tuberosities and the bicipital groove reappear on the medial portion of the head, but they are less distinct than they were on external rotation.

c. The cystlike appearance of the greater tuberosity, if previously

Fig. 6-A

Fig. 6-B

Case 6. G. R., aged forty-nine, male, clerk. This case illustrates the special fluoroscopic technique used to bring a subscapularis deposit into profile (See text).
Fig. 6-A: Right shoulder. External rotation fails to show clearly a large calcium deposit in the subscapularis portion of the short-rotator cuff.
Fig. 6-B: Right shoulder. External rotation plus body rotation throws the deposit clearly into profile.

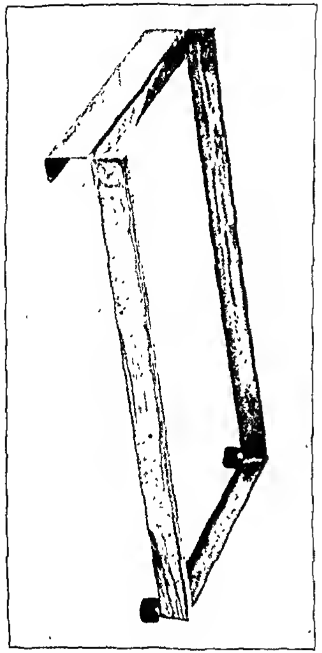

Fig. 7-A

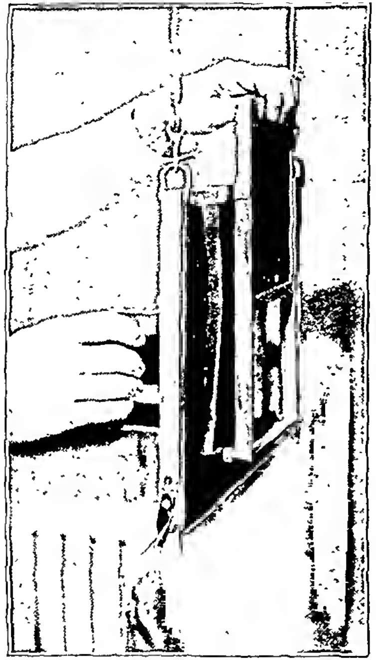

Fig. 7-B

Fig. 7-C

Fig. 7-A: The cassette holder.
Fig. 7-B: The cassette holder is hung on a fluoroscope screen. A cassette is being inserted.
Fig. 7-C: Set-up for fluoroscopy and spot-film roentgenography in the home. The cassette holder is supported by a double-jointed bracket which is clamped at one end to the holder, and at the other, to a chair.

seen, has disappeared, owing to superimposition of the lesser tuberosity on the greater, and of the glenoid fossa of the scapula on both.

The anatomical basis for these roentgenographic features will be appreciated upon an inspection of the disarticulated skeleton. Naturally intermediate degrees of rotation produce roentgenographic landmarks to some extent at variance with the above descriptions, but they will show a preponderance of the basic characteristics of one of these three positions.

A knowledge of how these positions may be obtained is essential for any one who desires to secure exactly comparable views at successive examinations. Full external rotation (Figs. 1-A and 1-C) is secured with the arm at the side, the elbow close to the body, and the forearm, flexed to a 90-degree angle, pointed as far laterally as possible. In mid-rotation (Figs. 1-B and 1-D), the arm occupies a similar position alongside the body, but the flexed forearm is pointed straight forward in the sagittal plane. For extreme internal rotation (Fig. 1-E), the flexed forearm is placed behind the back or, if this is impossible, on the chest. To view the lesser tuberosity with the subscapularis insertion in profile, the arm is placed in full external rotation and then the body is turned a few degrees in the same direction; if the body is not turned as well, the region of the lesser tuberosity will not be seen in profile and deposits in the subscapularis portion of the cuff may escape notice (Figs. 6-A and 6-B).

In the early days of this investigation an attempt was made to instruct the individual, during fluoroscopy, in what position the arm should be held, so as to bring the deposit into profile for subsequent roentgenography. This procedure soon had to be abandoned, however, because of the frequency with which a degree or two of rotation one way or the other from the correct position obscured the deposit. Time after time a deposit clearly seen by fluoroscope failed to appear on films taken later, simply through failure to have the arm in exactly the right position during roentgenography. This led to the development and adoption of the spot-film technique to be described.

With the deposit shown in profile by fluoroscope, a roentgenogram is taken, using a cassette holder (Figs. 7-A and 7-B), especially devised for that purpose, which is hung on the screen before fluoroscopy. The holder is a simple affair of channel brass, cut, bent, and brazed, according to a homemade pasteboard pattern, to fit a chosen cassette. It is readily fashioned by one mechanically inclined. Proper exposure can quickly be determined by trial and error; a short tap of the foot-switch (or a quarter of a second on the timer) sufficed in the author's experience.

In addition, the cassette holder has a small knob brazed to its under surface. By this means the holder may be supported by a jointed bracket, independent of the fluoroscopic screen. One end of the bracket is clamped to a chair, table, or stand, and the other end to the knob mentioned above (Fig. 7-C). This makes it possible for the owner of a small portable fluoroscope to employ the spot-film roentgenographic technique in the home as well as in the office.

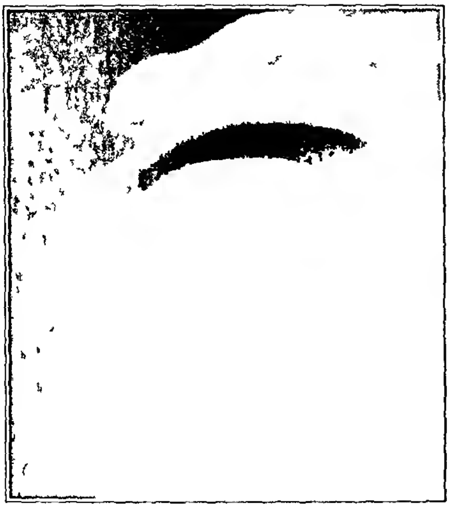

Fig. 8-A

Fig 8-B

Case 7. A K, aged thirty-seven, female, clerk. Three views of the same deposit, only one (Fig 8-A) shows the deposit in profile, thereby accurately localizing it, before operation, in the supraspinatus portion of the short-rotator cuff.

Fig 8-A External rotation Fig 8-B. Mid-rotation

Fig 8-C
Internal rotation.

It should be emphasized in this connection, however, that both fluoroscopy and roentgenography are inherently dangerous procedures, the indiscriminate use of which cannot be too strongly condemned. They should be undertaken only by those thoroughly aware of the possibility of burn to the operator, to the patient, or to both, either through overexposure or through the cumulative effect of repeated exposures. Fluoroscopic examination is particularly dangerous. Due to natural interest in, and concentration upon, the examination itself, one is apt to overlook the factor of exposure. The very simplicity and effectiveness of the procedure tend to make even an experienced operator careless in the course of time, and he must constantly check himself as to the protective measures he observes, and the amount of exposure to which he subjects himself. It is not enough to rely upon leaded gloves and apron and the use of a hand timer instead of a foot switch. They are no substitute for a careful training in roentgenographic technique, and this should be obtained before undertaking the procedures advocated in this paper.

Precise localization of the deposit by a technique such as that described is most important when operative removal of the calcium is contemplated. Figures 8-A, 8-B, and 8-C show three roentgenograms of a

shoulder, all taken at the same examination. It is evident that only one of the three (Fig. 8-A) was of value, from a surgical standpoint, in exactly locating the calcium deposit in the supraspinatus portion of the short-rotator cuff. Any one who has operated to remove these deposits will appreciate the extra advantage of thus knowing beforehand exactly where to look for the deposit.

In the event of multiple deposits in the same shoulder, a fairly common occurrence [2], as many as three or four roentgenograms are taken at one examination, rotating the arm under fluoroscopic control between exposures, to show each deposit in profile (Figs. 1-A, 1-B, 1-C, 1-D, and 1-E).

Roentgenography according to the above procedure necessarily suffers a slight distortion, mostly an enlargement of the roentgenographic shadow, due to proximity of the object to the tube; yet this magnification often proves to be an advantage, as it makes small deposits more visible. The spot-film method also involves the loss of a very small amount of photographic definition, but when fine bone detail is desired, further roentgenograms may be taken according to standard techniques [1]. Incidentally, the small size of film (five by seven inches or less) required by this method represents a material saving.

In conclusion, it is well to repeat that roentgenograms taken without fluoroscopic inspection and control frequently fail to show calcium deposits in the shoulder, the presence of additional deposits, or the precise location of the calcium within the tendinous capsule of the joint.

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THE TREATMENT OF BENNETT'S FRACTURE-DISLOCATION OF THE FIRST METACARPAL BONE

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The stave or boxer's or Bennett's fracture is an injury owing its origin to the disparity between an individual's pugnacity and his pugilistic technique[1]. It occurs typically when the full force of a blow impinges on the flexed thumb, instead of on the fist, with direct transmission along the first metacarpal shaft. The resultant fracture consists of an oblique break through the base with lateral luxation at the metacarpocarpal joint, and the proximal fragment, or medial angle of the base, remaining in its anatomical position. This is the characteristic pattern, though various degrees of comminution may occur. It is this resemblance on the roentgenogram to the forked staff of the medieval monk which accounts for the descriptive term "stave" (Fig. 2).

Fig. 1

Normal first metacarpal bone and joint.

It is customary to treat this injury in one of two ways. The more common method involves the application of a plaster encasement, after reduction with the thumb in full abduction and pressure over the basal portion of the bone in an attempt to reduce the luxation. The other method consists of traction in adduction by moleskin, or a wire through the shaft, with the apparatus mounted in plaster on the wrist and forearm. At the Beekman Hospital the former method has been employed almost exclusively.

About half of the ninety-six fractures of the first metacarpal bone treated during the last ten years were Bennett fractures. Of these, fourteen case records were sufficiently complete to merit detailed study. The clinical courses and end results of these cases are so uniform that they can be accurately summarized in one generic case history.

The patient, invariably a husky male, strolls into the clinic complaining of a swollen tender thumb following a fight or dimly remembered mêlée. Roentgenograms confirm the clinical diagnosis. Under local or even general anaesthesia, the thumb is manipulated, and the fragments restored to the anatomical position with fluoroscopic check-up. A plaster encasement is applied with the thumb in full abduction. Check-up roentgenograms, taken the next day, show a recurrence of the displacement

Fig. 2

Bennett's fracture, showing typical stave appearance, with the fragments straddling the greater multangular bone.

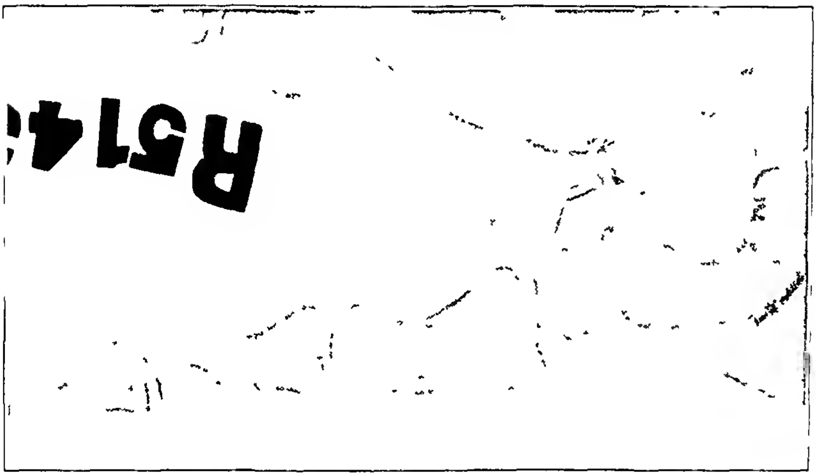

Fig. 3-A

Anteroposterior view of a healed Bennett's fracture, showing how the widened, concave, new base of the metacarpal rests upon the greater multangular.

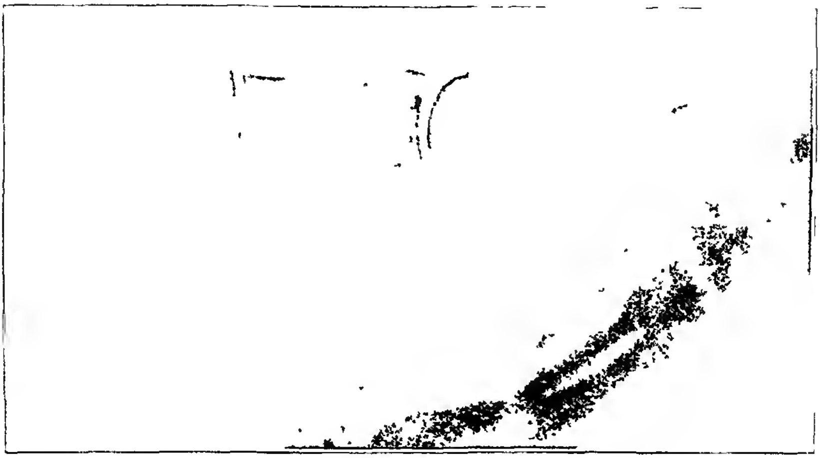

Fig. 3-B

Lateral view of a healed Bennett's fracture, showing widening and concavity of the new base of the metacarpal bone.

with most of the abduction evident in the metacarpophalangeal joint. If the patient continues to attend the clinic, and refrains from removing the plaster himself, the encasement is discarded in from three to five weeks, at which time the movement of the thumb is fairly good and not particularly painful. A few physiotherapy treatments are administered and the patient is discharged with an excellent functional result. However, roentgenograms show a structural change which is constant and, in the author's opinion, of significance in regard to the treatment of this injury. The interspace between the small medial proximal fragment and the distal displaced fragment, which consists of the rest of the metacarpal bone, is filled in with callus (See Figures 3-A and 3-B). By the end of the second month, a new joint mortise is formed, consisting of the broadened semicircular base of the healed metacarpal bone. This results in the construction of an enarthrodial (or ball-and-socket type) in place of the original diarthrodial joint (See Figure 1).

In view of the nature of the functional stress at this site, and the likelihood of recurrent trauma of the same kind as that which caused the original injury, the question arises as to whether the anatomical change which occurs, despite the best efforts to maintain the reduction, does not represent a more desirable end result than perfect reposition of the fragments with the restoration of the original joint outline.

With this viewpoint the next few cases were treated in the following typical manner: A physiotherapy treatment (radiant heat) was administered each day for the first two weeks. A narrow ace bandage was applied between treatments to the wrist and base of the thumb. The patient was allowed to use the thumb to the limits of pain. During the third week the patient was allowed to return to his occupation, unless it was exceedingly heavy work, and no further treatments were administered unless the swelling persisted. Full motion of the thumb was usually present. By the fourth week all crepitus and evident false-point motion on direct pressure over the site of injury had disappeared. At the end of the seventh week the roentgenograms showed the defect between the fragments to be filled in with a typical stave deformity of the base, of the type shown in Figures 3-A and 3-B. There was a characteristically complete range of motion of the thumb and a good grip.

If the malposition of the fragments in a Bennett's fracture is allowed to heal without reduction, a new joint mortise is formed. Thus the normal diarthrosis becomes an enarthrosis, or ball-and-socket type of joint.

In view of the difficulty of maintaining a successful reduction in this fracture-dislocation, and because of the real possibility that the joint changes mentioned above may represent a structural improvement over the normal, it is suggested that simple physiotherapy and bandaging to relieve the soft-tissue swelling constitute a shorter, simpler, and perhaps better method of treatment than that now in use.

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THE "PELVIC SUPPORT" OSTEOTOMY*

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Osteotomy of the upper end of the femur appears to have been performed for the first time by the American surgeon, John Barton. Since that time many types of upper femoral osteotomy have been devised and performed for special indications. In principle, these are linear or wedge osteotomies, performed at various levels and at assorted angles. Though each varies somewhat from the others, the difference between them is frequently more apparent than real. Functionally, these different procedures are essentially identical, in that they effect a medial shifting of the anatomical axis in relation to the mechanical axis of the femur. The resulting increased stability is characteristic of the group, and justifies the generic designation of "directional" osteotomy.

They have been presumed to differ radically from several other forms of osteotomy which the French[3] have called the "pelvic support" osteotomies. The two chief instances of this type are the "bifurcation" devised by Lorenz in 1917, and the operation suggested by Schanz in 1922. Though some authors have insisted that in these, as in the directional osteotomies, the beneficent effect is to be attributed to alteration in the relationship of the femoral axes, others have maintained that the resulting increased stability is due to actual support of the pelvis on the upper end of the osteotomized femur. Consequently, in order to insure the optimum support, considerable attention has been directed to a discussion of the exact site of pelvic abutment, or of the angle at which the femoral shaft is to be osteotomized. A still more lively controversy has developed concerning the respective merits of the high, versus the low osteotomy.

Some surgeons prefer the Lorenz bifurcation, or the Hass modification of this operation. For others, the Schanz osteotomy is the procedure of choice, because there appears to be less postoperative disability following this operation than after either of the other two. Although each of these operations can restore stability to the unstable hip, each may also result unfavorably, largely because of undue interference with hip motion. Study of a large series of these cases led to the conclusion that, in each of these operations, the important factor responsible for the limitation of hip motion was the excessive angle (postosteotomy angle) formed by the femoral shaft with a line drawn from the femoral head to the upper end of the osteotomized shaft of the femur.

Attention was first called to the problem during the course of a check-up on the results of cases in which the bifurcation operation of

* Received for publication on December 26, 1940.

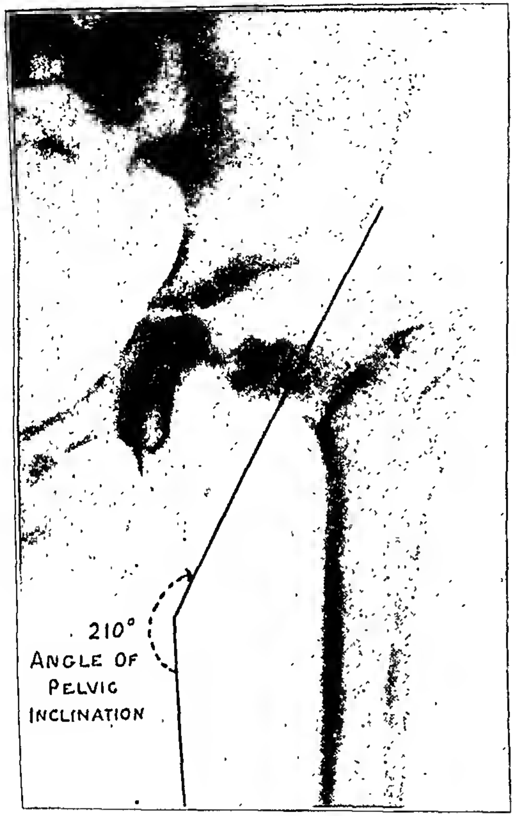

Fig. 1-A

Before operation. The femoral head is compressed and is only partly in the well-formed acetabular cavity. The angle of pelvic inclination shown by the drawn lines is equal to about 210 degrees. The intertuberosity distance between the ischial tuberosity and the lesser trochanter is clearly seen.

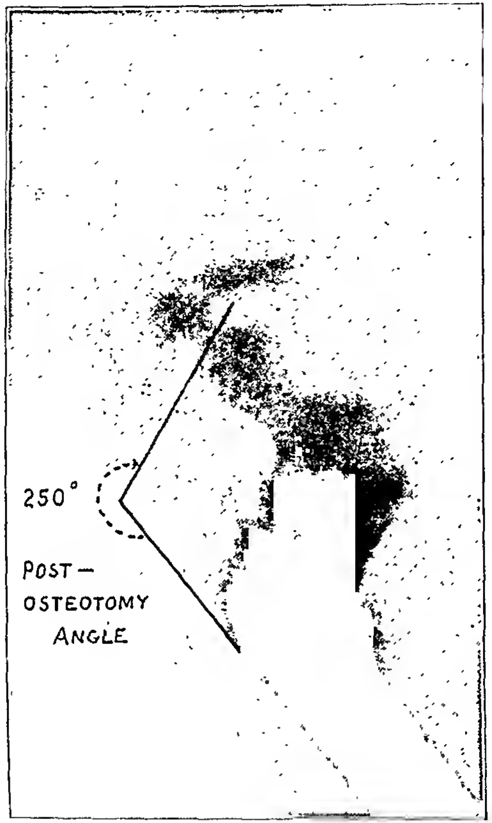

Fig. 1-B

A roentgenographically excellent bifurcation has been performed, but note, that as a result of the presence of the spike, the leg cannot be adducted. The postosteotomy angle, formed by the inner border of the shaft and the line drawn from the head to the tip of the spike, measures 250 degrees in a clockwise direction. The intertuberosity distance is obliterated.

Fig. 1-C

Four years following operation. The spike has largely disappeared. As a result of this, the leg is in only slight abduction. The post-osteotomy angle has been reduced to 210 degrees.

Lorenz or Hass had been performed bilaterally. Paradoxically, it was found that the roentgenographically "satisfactory" bifurcations almost invariably resulted in marked disability of a definite type.

Pain was present in varying degree. In some, the pain was so mild that it was overlooked in the satisfaction at the restoration of stability. In others, it was so severe that the patients insisted on relief. There was always an annoying increase in the intercrural distance, with an inability to bring the legs into parallelism. The patients could not completely flex or adduct the thighs. In the seated position they could not cross their legs, tailor-fashion. They could not assume the squatting position, and had difficulty in putting on their shoes and stockings. In the erect position, they stood with the legs abducted and the feet everted. Forward progress was possible only with a peculiar twisting and waddling gait, despite the fact that the Trendelenburg sign was usually negative.

On the other hand, and notably in children, it was observed that as the prong of the shaft fragment disappeared on the roentgenograms, the pain and disability vanished, usually without loss of the stability. This is typically illustrated in the following case.

S. O., a male, was first treated in 1923. When six weeks of age, a diagnosis of congenital dislocation of the left femur and congenital club-foot was made. When he began to walk he limped. The left hip was reduced by closed manipulation, but the child continued to limp. In 1932, an examination disclosed limitation of abduction and internal rotation, telescoping, and a shortening of the left, lower extremity. The roentgenogram (Fig. 1-A) revealed a marked deformity of the subluxated femoral head (traumatic epiphysitis). The acetabulum was fairly well developed.

On April 19, 1934, a typical bifurcation operation was performed, and a plaster-of-Paris spica was applied. Roentgenographically, it was believed that an excellent result had been obtained (Fig. 1-B). The well-formed prong of the lower fragment abutted against the anterolateral ischial wall, at about the level of the lower rim of the acetabulum. But the leg was held in wide abduction, and though its significance was not appreciated, a line drawn from the femoral head to the upper end of the osteotomized femur made, with the shaft, a postosteotomy angle of more than 250 degrees. In July 1934 the plaster was removed, and the patient was sent to a convalescent home. Upon his return, the mother noted that the child still walked with a limp, and experienced difficulty in putting on his shoes.

However, these disabilities tended to disappear with the lapse of time. In 1936, flexion at the hip was limited to 95 degrees and internal rotation was possible to only 10 degrees beyond the neutral position. In 1939 flexion had increased to 80 degrees and adduction was possible to 30 degrees beyond the neutral position. In 1940 adduction had still further increased to 45 degrees. The mother noted that the patient had markedly improved. The limp was only slight, there was no pain or discomfort, and the patient could cross his legs or put on his shoes without difficulty. The roentgenogram (Fig. 1-C) disclosed the explanation,—the bifurcation spike had almost completely disappeared, and the upper end of the femur presented somewhat the appearance seen after a high Schanz osteotomy. With the pelvis level, the femur was almost parallel to the sagittal plane of the body. The line joining the femoral head to the upper end of the femoral shaft formed, with the axis of the femur, an angle which had been reduced to less than 210 degrees.

Such marked improvement, invariably observed in children following absorption of the bony prong, suggested that in adults, in whom disability

Fig. 2

The femur has been osteotomized, and the upper end of the distal fragment has been placed against the external ridge of the ischium. The leg is in an almost neutral position.

Fig. 3

The distal fragment has been slightly abducted, and the upper end of the spike has been directed forward.

persisted, similar relief might be obtained by surgical amputation of the offending spike of bone. Before this was undertaken, the action of the spike was studied directly on the skeleton. With the femoral head in the acetabulum, the shaft of the femur was cut in the plane of the Lorenz osteotomy and its upper end was displaced medially, without abduction, until it made contact with the pelvis, along the external border of the ischium. It was found that rotation was only slightly limited, but that flexion and adduction were moderately limited (Fig. 2). This was obviously caused by the impingement of the femoral shaft against the side of the pelvis. In effect, the intertuberosity distance, between the ischium and the lesser femoral trochanter, had been obliterated with resulting limitation of motion.

When the distal fragment was abducted and directed forward against the anterolateral wall of the ischium, so as to simulate the Hass modification of the Lorenz osteotomy (Fig. 3), it was noted that, with increasing abduction of the distal fragment, rotation, especially internal rotation, was proportionately diminished. When the upper end of the osteotomized fragment was directed backward against the posterolateral surface of the ischium, limitation of flexion, adduction, and especially external rotation, resulted. Invariably it was observed that the interference with motion was due to the impingement of the spike against the lateral projection of the ischial tuberosity.

The reason for this becomes clear when the pelvic girdle is examined. Due to the posterior interposition of the sacrum, the os innominatum is set obliquely into the pelvic ring. In consequence of its forward and inward direction, the body of the ischium presents an external border, which separates its anterolateral surface from its posterolateral surface, including the tuberosity. The external ischial border, together with the posterior rim of the acetabulum, forms a ridge, which, except for the flare of the ilium, presents the most lateral projection of the pelvis. The ridge is always visible on the roentgenogram, and, with the sagittal plane of the pelvis, affords a measure of the angle of inclination of the outer pelvic wall (Fig. 4). It is apparent, therefore, that when the osteotomized shaft makes contact with the pelvis, at any point other than along this ridge, the point of contact must lie medial to the ridge, and must lead to interference with rotation when the femoral head is fixed.

The head of the femur was then dislocated posteriorly onto the ilium, and the same experiments were repeated. Essentially, the same results, with one exception, were obtained. When the osteotomized shaft was displaced into the acetabulum according to the described technique of the operations, the most marked limitation in all arcs of motion was obtained. This was immediately recognized as being caused by the steeply sloping walls of the acetabular cavity, which, like the ridge, acted to obstruct the motion of the spike (Fig. 5). This observation is of special significance, because of the expressed opinion that "the osteotomy is merely the preparatory step in the [bifurcation] operation. The

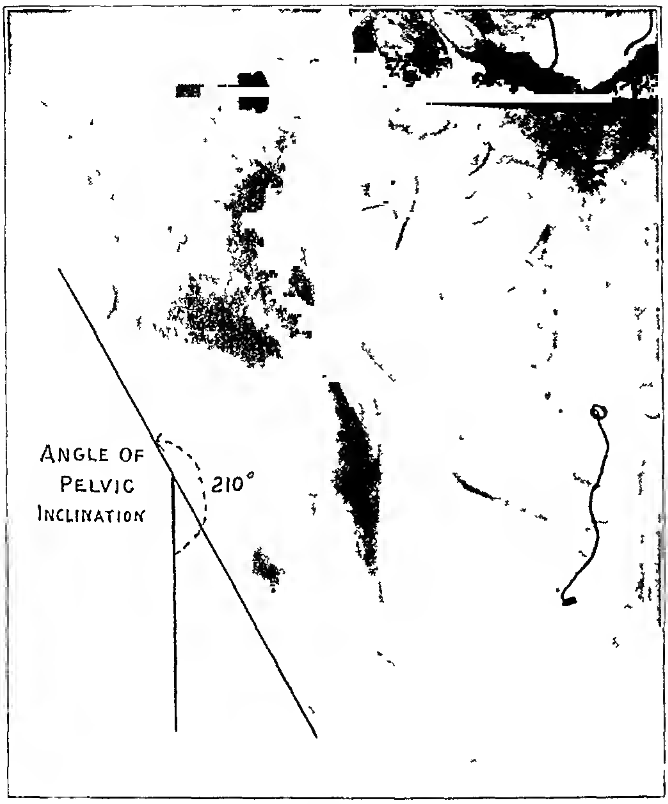

FIG. 4

On the roentgenogram, the outermost contour of the pelvis is determined by the external ridge of the ischium and the posterior rim of the acetabulum. With the sagittal plane of the body, this line makes an angle of about 210 degrees, which will be called the angle of inclination of the outer pelvic wall.

essential act is the reposition of the distal fragment into the acetabulum"[2]. Quite the contrary, it was found that, in the presence of a femoral head and neck, the acetabular position of the distal fragment was the worst of all the sites of pelvic abutment, and that the consequent limitation of motion could only be overcome by resection of the spike (Fig. 6). However, when the femoral head and neck were amputated, the acetabular position of the fragment acted to restore good balance and stability, without limitation of motion. Though this outcome could have been predicted from the principle that simultaneous, universal motion about each of two separate point fulcra is impossible in three-dimensional space, the studies demonstrated conclusively that the acetabular position of the bifurcation spike is to be avoided, except in those conditions in which the instability results from a pathological loss of the head and neck.

From these experiments, it appeared reasonable to conclude that the spike itself was the cause of the disability which these patients presented, and with some slight misgivings, the first patient was re-operated upon for resection of the projecting spike. The improvement was sufficiently encouraging to warrant other such attempts. The results of the first of these efforts have been reported elsewhere[5]. Briefly recapitulated, they indicated that stability could be preserved, despite removal of the spike. Pain disappeared immediately, and the range of hip motion was usually increased in proportion to the degree in which the bony projection was removed. But even complete amputation did not necessarily result in an invariably satisfactory outcome. In some cases, an almost normal range of motion was obtained. In others, the pelvic tilt noted in unilateral cases, persisted. This seemed to be due to excessive abduction

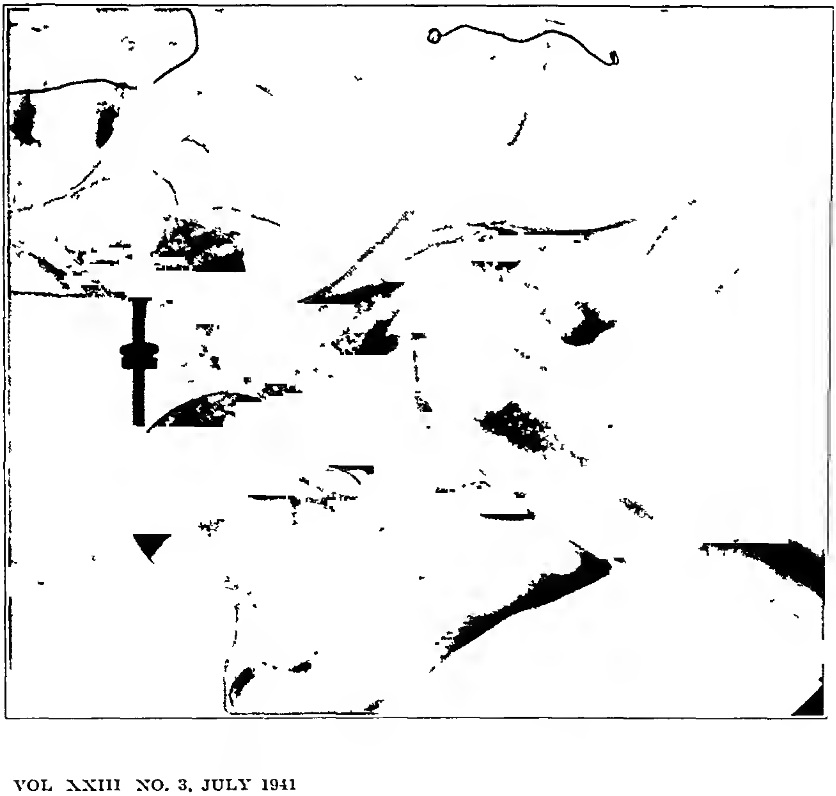

FIG 5

The femoral head has been dislocated, and the spike is in the acetabulum. The leg is in marked abduction.

FIG. 6

The spike has been resected so that its upper end lies in the plane of the outer pelvic wall. The bone has been cut at the same angle, but the leg as a whole can be brought into greater adduction than in Fig 5

of the distal fragment, and clearly indicated the necessity for removal of the apex of the osseous angle projecting medially at the site of osteotomy.

This was performed with satisfactory outcome in the following case:

Frieda S., aged fifty-five, was first seen in the Out-Patient Department in January 1936. She had been in an automobile accident the previous summer, and walked with the aid of a cane, holding the knee, hip, and trunk flexed. The left thigh was externally rotated. Extension at the hip was limited to 150 degrees, and flexion to 85 degrees. Roentgenograms taken at this time showed a traumatic dislocation of the femoral head with numerous free fragments of hone in the soft tissues about the hip from a comminuted fracture of the margins of the acetahulum. Admission to the hospital for an operation to restore stability was advised.

On January 30, 1936, a bifurcation osteotomy in the sagittal plane was performed. The operation was earried out expeditiously, and the postoperative convalescence was uneventful. In September of 1936 the patient was able to stand without the aid of crutches. A mild degree of valgus of the knee was noted. In December 1936, the patient walked about without the aid of erutehes. The roentgenographic report in 1937 stated, "exeellent osteotomy, with the upper end of the distal fragment located at the lower quadrant of the acetabulum, in neutral position".

Re-examination in June, 1939, diselosed that the patient still walked with a slight limp and a waddle, but the Trendelenburg sign was negative. In the erect position the foot was held in the neutral position. Flexion was possible to a right angle, extension to 180 degrees, internal rotation to 15 degrees, external rotation to 60 degrees, abduction to 60 degrees. Despite this exeellent are of mobility in the ereet position, the patient was unable to eross her legs, tailor-fashion, or, when seated, to put on her shoes without diffieulty.

The roentgenogram (Fig. 7-A) showed a marked anteversion of the femoral head with an osteotomy of the high Schanz type. Careful examination of the plate disclosed an overlap of the shadows east by the osteotomy angle and the body of the ischium. The impression was obtained that the apex of the osteotomy angle impinged against the ischium, in front of the external ridge, and so tended to restrict internal rotation. This was, of eourse, due to the relative shortening of the femoral neck, caused by external rotation of the upper fragment.

In effect, the intertuberosity distance had been reduced by a mechanism somewhat different from that seen in Figure 2. That this patient had a relatively good range of motion in the erect position, with limitation in the seated position, suggested the explanation that in the standing position the excessive angulation could be easily compensated for by tilting the pelvis, while in the seated position this became impossible, and a limitation of motion, not otherwise annoying, was brought to light.

The indication was obviously to re-osteotomize the femur, for the purpose of redueing the excessive abduction. The patient, however, refused to submit to any operation that would necessitate immobilization in plaster of Paris. To overcome this objection, it was deeided to resect the apex of the bony angle. The patient was readmitted to the hospital and operated upon February 27, 1940. With the patient under anaesthesia, the range of motion was again tested. However, even then, with both legs held parallel, internal rotation was impossible beyond the neutral position. Through an anterior approach, using the descending arm of the Smith-Petersen incision, the site of osteotomy was exposed. The upper end of the femur presented a peculiar spiral twist from below, and medially to upward, outward, and backward. The upper fragment was obviously flexed, and, in addition, was excessively adducted, so that an angle, of which the apex pointed forward and inward, was formed. When an effort was made to adduct and internally rotate the leg, it was clearly seen that the angle of the osteotomy abutted

FIG 7-A

Osteotomy performed for a traumatic dislocation of the femur Note that the apex of osteotomy angle overlaps the shadow of the ischium, though the postosteotomy angle is about equal to the angle of inclination of the outer wall of the pelvis, the forward rotation of the neck has resulted in relative shortening of the neck, so that the osteotomy angle is displaced medially.

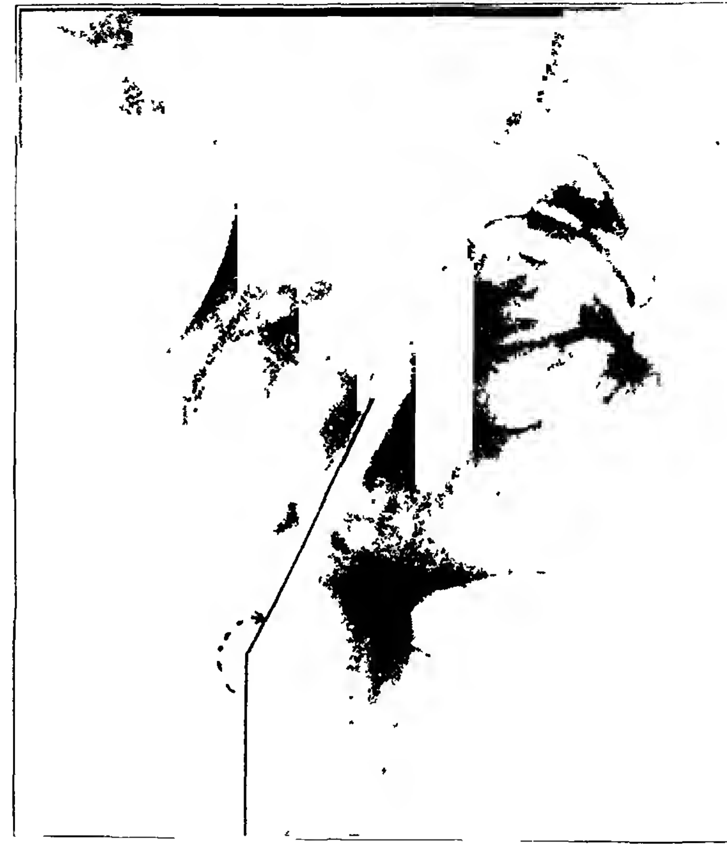

FIG. 7-B

Postoperative. The apex of the angle has been resected and the postosteotomy angle is about equivalent to that of the inclination of the outer pelvic wall.

against the pelvis and prevented rotation. The medially projecting portion of this angle was resected in the sagittal plane, and the wound was closed in the usual manner, without drainage and without plaster immobilization. Immediately after operation it was noted that internal rotation was possible to 25 degrees beyond the mid-line.

Within a week of her operation the patient was permitted to bear weight. No loss of stability was apparent, and the patient observed that there was a marked improvement in the range of motion. She was able to bend down to put on her shoes, and was able to cross her legs in the seated position. The roentgenogram (Fig. 7-B) showed that the angle of the osteotomized femur had been reduced, so that it was about equivalent to the angle of inclination of the outer pelvic wall.

This case proved of especial interest, because it demonstrated the essential identity of the effects produced by the bony spike of the Lorenz operation and the projecting bony angle typical of excessive abduction or flexion in the Schanz operation. It established the fact that the block which these bony prominences caused was due to excessive abduction of the distal fragment, and could be readily eliminated. The only question which remained was the determination of the amount of bone which had to be removed in order to insure restoration of motion.

When stated in this form, the question appeared to be one which could be answered only by the slow accumulation of individual experiences. However, if the question were the determination of the degree to which the distal femoral fragment can be abducted without limitation of motion at the hip, the problem seemed much simpler of solution. In his original contribution, Schanz pointed out that hip stabilization resulted from the application of the pelvis against the femoral shaft. Consequently, for practical purposes, the angle of *abduction* of the distal fragment in relation to the proximal fragment has been taken to be about equal to the degree to which the affected limb can be *adducted* when the pelvis is level. But at best this is only a rough approximation to the desired optimal angulation. From what has gone before, it is clear that, to a large extent, the result obtained will depend upon the exact point at which the femur makes contact with the pelvis. Even presuming that this site could be predetermined with any assurance, it can be readily shown that at any given point, the angle of abduction will vary considerably with the level at which the osteotomy is performed. It is in all probability the uncertainty introduced by these variable factors which accounts for Gaenslen's observation, "Some limitation of motion is not unusual, especially in flexion and adduction, but this is less than that following the bifurcation operation. . . ."

Since this limitation of motion is due to bony impingement of the femur against the pelvis, it is obvious that the postosteotomy angulation of the femur must not exceed the normal angle of inclination of the outer wall of the level pelvis. In this determination, the relationship of the distal to the proximal portions of the femur plays only a secondary rôle. The important part is played by what has been called the postosteotomy angle,—that is, the angle formed by the shaft and a line uniting the femoral head to the upper end of the distal fragment.

This can be readily demonstrated by the following considerations: The normal femur is a hockey-stick-shaped structure which may be schematically represented by a triangle. The shaft, or anatomical axis, forms the outer boundary, the anatomical neck forms the upper boundary, and the mechanical axis, displaced by the medial projection of the neck, forms the inner boundary (Fig. 8-A). The important fact to stress is that the femoral neck which may be defined as the connection between the femoral head and the upper end of the shaft is directed medially, and that as a result the angle of the femoral neck opens medially and is less than two right angles.

Now, the function of femoral osteotomy is to change the line of weight-bearing stresses. This is accomplished by abduction of the distal fragment with reversal of the normal relationship of the femoral axes. As the abduction increases, the medially placed mechanical axis shifts outward, so that ultimately it comes to lie lateral to the anatomical axis. Progressively, the normal angle of the femoral neck increases to a straight angle, and ultimately to an angle which opens *laterally* instead of *medially*. In other words, the direction of the effective femoral neck has been reversed so that it, too, points laterally. The original anatomical neck remains unaltered, but a new neck, which consists of the anatomical neck plus that portion of the shaft proximal to the osteotomy, has been formed. This fragment as a whole constitutes the effective femoral neck, and the line which connects the femoral head with the upper end of the osteotomized femur forms what may be called, by analogy, the mechanical neck of the femur (Fig. 8-B).

This concept of the mechanical neck of the femur acquires additional significance when an effort is made to analyze the action of a Lorenz type of osteotomy. Here the upper end of the distal fragment is displaced upward, with the result that the mechanical femoral neck lies at some distance above the effective femoral neck (Fig. 8-C). It is the line joining the head to the upper end of the distal fragment—the mechanical neck of the femur—which forms, with the shaft, an angle whose importance has been overlooked. This angle, which has been called the postosteotomy angle, must be carefully differentiated from the angle of abduction at the site of osteotomy.

It is this postosteotomy angle, rather than the abduction angle between the proximal and distal portions of the osteotomized femur, that is of critical significance. In the simple abduction osteotomies, the postosteotomy angle normally increases proportionately with the angle of abduction. In the Lorenz osteotomy, however, the postosteotomy angle can be increased to any given amount by simple upward displacement of the distal fragment without any corresponding increase in the abduction angle (Fig. 8-C). This being the case, it is apparent that regardless of the degree of abduction, it is the postosteotomy angle which must be controlled. Since the apex of this angle is directed medially, it is clear that this angle must not be permitted to exceed the angle of inclination

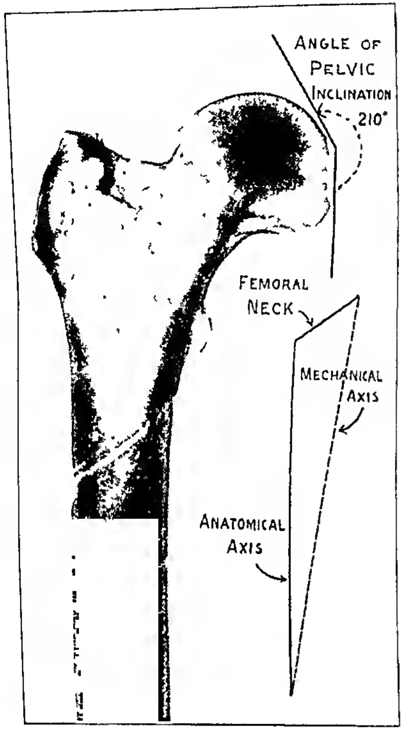

Fig. 8-A

The normal femur may be schematically represented as a triangle. The anatomical neck forms the upper boundary, the anatomical axis or shaft the outer boundary, and the mechanical axis the medial boundary. The neck is directed medially, and the angle of the femoral neck, less than two right angles, opens medially.

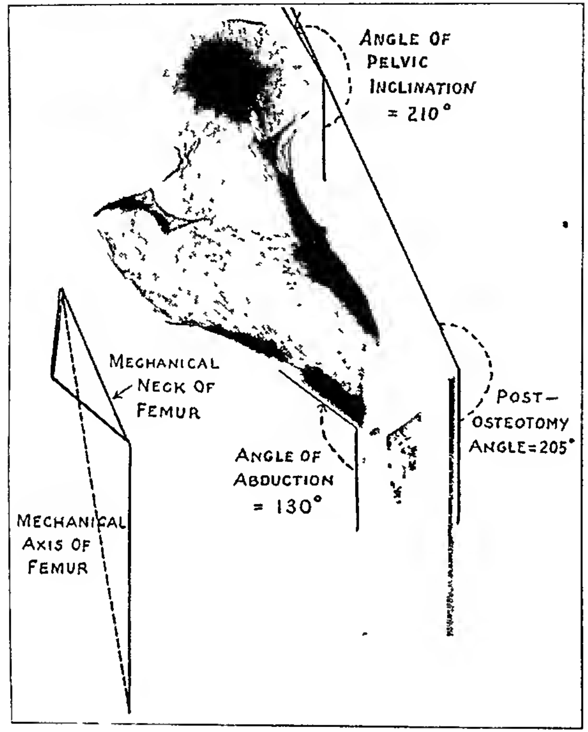

Fig. 8-B

Osteotomy of the Schanz type creates a new femoral neck, consisting of the anatomical neck and the proximal portion of the osteotomized shaft. For the purpose of this illustration, the appearance of the Schanz osteotomy has been simulated by opening a wedge on the inner side, instead of removing a wedge from the outer side. The upper fragment, directed outward, constitutes a new *mechanical* neck of the femur, which, with the shaft, makes the postosteotomy angle larger than two right angles, and opening *outward*. This angle is equal to 205 degrees and is less than the angle of pelvic inclination of 210 degrees. The mechanical axis has shifted from the medial to the lateral side of the femur.

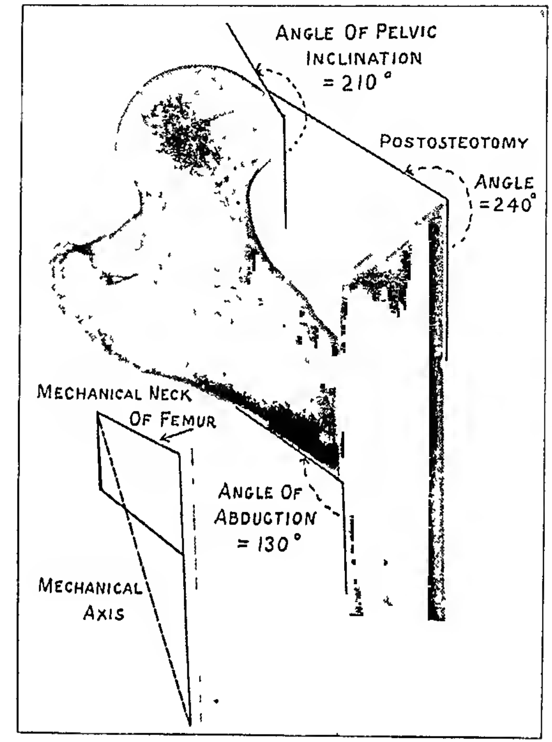

Fig. 8-C

Osteotomy of the Lorenz type displaces the mechanical neck of the femur above the effective femoral neck. As compared with Fig. 8-B, the angle of abduction is identical, but the postosteotomy angle has been increased to 240 degrees. The intertuberosity space has been eliminated. To avoid limitation of motion the spike must be resected so that the postosteotomy angle is less than 210 degrees, or the angle of pelvic inclination must be increased by pelvic tilt so that it is greater than 240 degrees.

of the outer pelvic wall. If this does occur, in the coronal plane, normal parallelism of the legs is impossible, and both adduction and rotation are impeded. If it occurs in the sagittal plane, as by excessive flexion of the proximal fragment, flexion of the leg is limited.

Since the degree of stability of the hip increases with the lateral displacement of the mechanical axis, there has been a natural tendency to increase the abduction of the distal fragment so as to achieve the maximum shift. In unilateral cases, abduction of as much as 45 degrees, and even 60 degrees, have been suggested. In the erect position, the excessive postosteotomy angle, which such abduction determines, can be readily compensated by a tilting of the pelvis, which in effect increases the angle of pelvic inclination. (This of course presupposes the possibility of a corresponding adduction of the opposite leg, so as to permit parallelism in normal progression.)

It was the consideration of this point which furnished the clue to the whole problem. Where pelvic tilting was limited, from whatever cause, or where parallelism of the legs was impossible, limitation of motion necessarily resulted. In bilateral cases, in which excessive postosteotomy angles were formed, adduction of the opposite leg was limited, and adequate compensatory tilting of the pelvis was impossible. In the seated position, where also pelvic tilting was impossible, the large postosteotomy angle similarly hampered the patients in crossing their legs or in putting on their shoes. Clearly, the indication was the reduction of the postosteotomy angle so that it was equal to, or preferably less than, the angle of pelvic inclination. By actual measurements on the roentgenograms, this angle varies between 210 and 230 degrees, and experience indicates that the postosteotomy angle should, in general, not exceed the lower figure.

Once this concept became clearly defined, its general validity in all types of upper femoral osteotomy seemed apparent. When it was applied to the consideration of the Lorenz bifurcation, a very interesting observation was made. In principle, the Lorenz bifurcation consists of two separate steps: (1) the abduction osteotomy, and (2) the upward displacement of the distal fragment. The function of the first of these elements has already been discussed. Strange though it may seem, the action of the second is directly to overcome the effects accomplished during the first stage. It can readily be demonstrated that the upward displacement tends to decrease both the stability and the range of motion which results from abduction.

During its first, or abduction phase, the Lorenz bifurcation presents essentially the same mechanical picture as the Schanz osteotomy. Abduction of the distal fragment has resulted in lateral shifting of the mechanical axis, so that stability is increased. The postosteotomy angle has been increased, and, for the sake of the argument, it will be assumed that it has been increased to the point where the maximum of stability without limitation of motion has been achieved. At this point, the pelvis

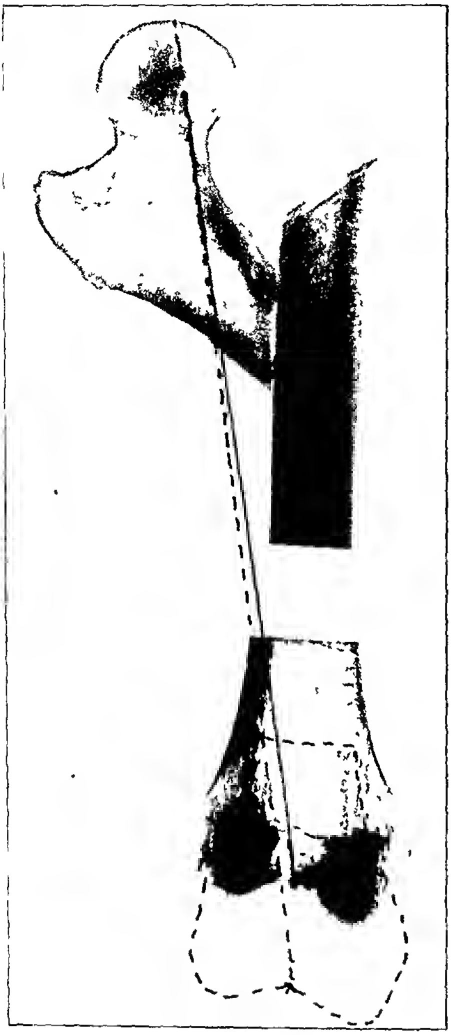

Fig. 9

Osteotomy of the Lorenz type shifts the mechanical neck of the femur upward, with consequent increase of the postosteotomy angle to much beyond the angle of pelvic inclination, as in Fig. 8-C. In the simple abduction osteotomies, increase in this angle is associated with a corresponding lateral shift of the mechanical axis and increased stability. However, because of femoral shortening, the mechanical axis is here shifted more medially, with relative decrease in stability for any given degree of abduction.

is still level and the legs are parallel. Now the second phase of the operation is performed. Maintaining the same degree of abduction, the distal fragment is displaced upward, until contact with the pelvis takes place. Promptly thereafter, limitation of adduction, rotation, and even flexion, occur. Clinical observations and experimental study amply establish the fact that this is due to projection of the bony spike formed by the upper end of the osteotomized shaft. It could be hoped that, for the resulting loss of motion, a proportionate increase in stability might be achieved. But exactly the opposite occurs.

From a mechanical point of view, the upward displacement of the shaft acts to shift the mechanical neck of the femur upward, and so to increase the size of the postosteotomy angle. In all other osteotomies, the increase in this angle necessarily implies a *lateral* shifting of the mechanical axis and a tendency to increase stability. In the Lorenz osteotomy, because of the shortening of the femur as a whole, the mechanical axis moves *medially*, and, for the same angle of abduction, tends to *diminish* the stability. It is only by further increasing the abduction, and so decreasing the mobility, that the stability previously obtained can be preserved (Fig. 8-C).

The observations here made in regard to the Lorenz operation apply with even greater force to the operative modification suggested by Hass. In his operation, the upper end of the distal fragment is displaced forward, as well as inward. The flexion of the proximal fragment, combined with this forward inclination of the upper end of the distal fragment, tends to yield that degree of excessive anterior angulation to which Gaenslen called attention in discussing the Schanz osteotomy. It appears that, whatever the angle may be, the formation of a spike tends to defeat the purpose for which it was devised.

For any desired degree of stability, the spike imposes the necessity of greater abduction and the assurance of limitation of motion. For any desired degree of mobility, it imposes the necessity of decreased angulation with the assurance of diminished stability. In fact, its greatest field of usefulness seems to be precisely in those conditions, such as tuberculous coxitis, in which limitation of motion may be desirable.

The therapeutic implications of these considerations are immediate. The formation of a spike should be avoided. The osteotomy should be performed in the plane of the anatomical neck of the femur. The angle of abduction of the distal fragment of the femur should be such that the post-osteotomy angle is less than the angle of pelvic-wall inclination. These elements in the successful performance of femoral osteotomy impose the necessity of careful control of the osteotomized fragments. For this reason, exposure of the femur through an anterior incision, careful execution of the osteotomy, and subsequent control of the fragments by plaster or by pins incorporated in the plaster, seems advisable. Postoperative roentgenograms with actual measurement of the postosteotomy angle are imperative in determining the need for increasing or decreasing the angulation of the distal fragment.

If the patient is seen some time after union of the osteotomy has occurred, and disability persists, revision of the operation should be advised. Whenever possible, the spike, if present, should be amputated. Where the angulation is not too great, the apex of osteotomy may be resected sufficiently to reduce the angle to below that of the pelvic wall. However, if the angulation is so great that simple resection cannot be safely carried out, osteotomy and reduction of the degree of abduction must be performed.

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THE USE OF NEOARSPHENAMINE IN THE TREATMENT OF ACUTE STAPHYLOCOCCUS AUREUS SEPTICAEMIA AND OSTEOMYELITIS *

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The use of arsenic compounds in the treatment of staphylococcus aureus septicaemia was first attempted by the authors in 1932. At that time an acute osteomyelitis of the femur had developed in a girl, as a complication to an acute empyema and suppurative pericarditis. The blood culture revealed the staphylococcus aureus to be the offending organism. It was suggested that neosalvarsan, which had been used with good results in pyelitis due to staphylococcus aureus infection, might be beneficial. The drug was used and a recovery effected. The infected femur was, of course, drained and treated according to accepted methods.

Following this experience, Dr. D. H. Nickson made some laboratory tests to determine the effect of arsenic compounds on the staphylococcus aureus in culture. It was found that, on test plates, growth of the staphylococcus aureus was inhibited in 1:100 dilutions of neosalvarsan; dilutions of 1:100 up to 1:1000 retarded growth, but did not inhibit it; and dilutions greater than 1:1000 had no effect on the organism.

During the last eight years, all cases of acute osteomyelitis have been treated on the assumption that a septicaemia caused by staphylococcus aureus existed. Early surgery, when not contra-indicated, has been carried out. The blood culture has been made in the operating room, and the first dose of arsenic has been given on the operating table. If the blood culture showed no growth, no further use of arsenic was made. If the blood culture was positive, arsenic was continued over a period of some days.

The following is a comparison of the results which have been obtained by the use of neoarsphenamine with results obtained prior to its use.

The number of records examined was 131, of which sixty-six were selected. The arbitrary basis for this selection was that no patient whose record was summarized had a temperature of less than 101 degrees on admission, had an illness of prolonged duration, or one that was an exacerbation of a chronic osteomyelitic infection. In other words, only the acute, fulminating types of infection were considered. There were forty-four males and twenty-two females. The average age in years was eight and one-half. The average duration of the symptoms was six days. The average temperature on admission was 103.2 degrees, or 104 degrees rectal temperature.

The location of the disease in this series followed the usual course, the tibia and the femur being the most usual locations of the infection.

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, New Orleans, Louisiana, January 14, 1941.

Of the sixty-six patients selected for this study, fifty-three had blood cultures made, while thirteen did not. This laxity in the making of blood cultures may be partially explained by the fact that the series of cases runs back to 1927, or thirteen years. Of the cultures of the fifty-three patients for whom blood cultures were made, thirty were found to be positive and twenty-three negative.

No patient having a negative blood culture died, whereas there were thirteen deaths in the group with positive blood cultures. Twenty-three, or 100 per cent., of the patients with negative blood cultures recovered. In the group with positive blood cultures, seventeen patients recovered. In other words, in this group of fifty-three patients for whom blood cultures were made, there were forty recoveries and thirteen deaths.

To come back to the use of arsenic in the treatment of acute staphylococcus aureus septicaemia and osteomyelitis, this drug has been of great benefit in reducing the rate of mortality. In recent studies Osgood, of the University of Oregon Medical School, has conducted extensive research on the effectiveness of neoarsphenamine, sulfathiazol, sulfanilamide, and sulfapyridine in the therapy of staphylococcus aureus infections in marrow cultures. He has shown that sulfathiazol and sulfamethylthiazol in dilutions of 1:10,000 are definitely inferior to neoarsphenamine in dilutions of 1:150,000 to 1:200,000 in destroying the staphylococcus aureus in marrow cultures.

Of the thirty patients who showed positive blood cultures, twenty-one received neoarsphenamine; of these, five, or 24 per cent., died and sixteen, or 76 per cent., recovered. Of the nine who received no neoarsphenamine, eight, or 89 per cent. died, and one, or 11 per cent., recovered.

Dosages used have been more or less empirical. The routine has been to administer an initial dose of 0.15 grams, and to increase the dose gradually every three days to a maximum of 0.45 grams. In no case have more than seven doses of the drug been administered.

According to Osgood's recent work the dosage should be: body weight in pounds divided by 330; this indicates the total dose to be given on the first day in three or four divided doses. Each subsequent day three-fourths of this dose is administered, divided into three spaced doses, and this is carried on until the patient has been afebrile for six to ten days.

CONCLUSIONS

Neoarsphenamine is a powerful weapon in combating septicaemia and acute osteomyelitis due to the staphylococcus aureus. The death rate has been markedly decreased through its use. It is hoped that the drug may find wide general use and be subjected to further clinical study.

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THE TIMING OF THE FRACTURE-HEALING PROCESS

Its Influence on the Choice and Application of Treatment Methods*

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Based upon the intensive research of the last quarter century into the nature of the tissue reaction following fracture, the author is of the opinion that there is today a reasonably clear idea of what takes place, although the whys and the hows are still in many respects hazy or unknown. He believes that one may accept as reasonably certain, on the basis of both experimental and clinical evidence, the following as the probable course of events in the "average" or "normal" case:

1. Tissue death and hemorrhage in both soft parts and bone as result of trauma. This is immediate.
2. The reaction of inflammation secondary to the autolytic products of tissue death and hemorrhage into the tissues,—the outpouring of inflammatory exudate, and the stagnation and engorgement of the local minute circulation in tissue spaces, lymphatics, and ultimate capillaries. This occurs in a space of hours.
3. The creation of a markedly lowered pH in the local tissue fluids by these products of tissue death and hemorrhage, until such time as the local minute circulation can disperse them.
4. The formation of a fibrin network by the clotting of hemorrhage and exudate.
5. The progressive decalcification of bone as long as it lies in tissue fluids of a markedly low or acid pH.
6. The appearance and growth of undifferentiated connective-tissue cells along the fibrin network joining the bone ends and surrounding tissues. This can be seen as early as twenty-four to thirty-six hours after injury.
7. The accumulation of unprecipitated or undeposited calcium in some undetermined form in this tissue network, apparently in connection with the fibrin of clot and the collagen of the undifferentiated new tissue. This starts as early as the fibrin formation and continues as long as the dual condition of local calcium accumulation and the presence of collagen or fibrin in a low or acid pH exists.
8. Gradual rise of the local tissue fluid pH from the acid level by reason of the dispersion of the autolyzed products of tissue death and the products of local tissue metabolism by increasingly efficient local minute circulation.

*Read before the American Academy of Othopaedic Surgeons, New Orleans, Louisiana, January 15, 1941.

9. Deposition of the accumulated calcium in the newly formed undifferentiated tissue. There is sufficient evidence to support strongly the supposition that this occurs when the pH of the local tissue fluids has risen to a point where a phosphatase can become active. This is callus formation.

10. There is adequate support for the viewpoint that, if the new tissue becomes differentiated into adult formed connective tissue before the pH of the tissue fluids has risen to a point where phosphatase activity is possible, no calcium deposition occurs. A so-called fibrous union takes place instead. If the pH rises to a point which allows only minimal phosphatase activity, a slow calcium deposition occurs, but ceases as a local healing process when tissue differentiation is complete.

It is obvious that chronological time in this story means little or nothing save as an "average" figure, because of wide variations in the severity and extent of tissue damage, and of anatomical factors which affect the speed of progress of the pathological process. "Time" refers to the stage of progress which the pathological condition has reached. It is to be interpreted in terms of clinical evidence,—such as the character and extent of swelling, pain, tenderness, oedema, infiltration, and ecchymosis. The stage of progress which is reached at the end of eight hours in the "average" case may be reached or passed in two hours in a severe case, or may not be attained for twelve, sixteen, or twenty-four hours in others less severe or differently situated. But the actual place in "time" of each of these cases is definitely proclaimed to careful examination by the patient's signs and symptoms. The logical rule to follow is to treat the fracture in accordance with the pathology present, regardless of chronological time elapsed since injury, by modifying whatever method the surgeon is best capable of handling effectively. A standard treatment applied early in point of pathological progress may be eminently successful, and as eminently unsuccessful if applied late; the reverse of this is also often true. The difference in significance of the terms "early" and "late" does not mean a question of weeks, or for that matter even days, but may have to be interpreted in terms of a very few hours.

This brief résumé of a viewpoint is necessary to consider how treatment may affect the timing and progress of this process, or, conversely, how treatment may have to be modified according to the stage at which treatment is undertaken. It is obviously impossible to enter into a prolonged discussion of the viewpoint itself in this paper. However, an annotated bibliography which covers the pros and cons of the problem both from the academic and the clinical side is appended.

It is proposed to illustrate the influence of the timing of the process on the choice of method, and on the manner of carrying out the chosen method, by citing clinical conclusions which have been reached on a Service where the technique of treatment has been developed for the last twelve and a half years on the basis of the expected effect on the pathological situation present at the time of treatment. The conclusions are

drawn from the clinical results obtained by treatment methods and technique developed on this principle in something over 13,000 fracture cases.

1. The "time" schedule of the development of tissue reaction after fracture dictates the technique of traction-suspension as a method of treatment. Reduction, in so far as length is concerned, should be attained within a few hours. The author likes to get it in four hours. Every effort should certainly be made to get it within the twelve-hour period. The underlying principle is to get the normal length while the muscles are still elastic and can be stretched without damage and with minimum effort. Depending upon the severity of the trauma this elasticity is lost in from four to sixteen hours, and stretching of the muscle can then no longer occur. The muscle is infiltrated with hemorrhage, exudate, and fibrin, and is subject to the laws of hydraulics rather than to those of elastic bodies. The common failing is to underpull in these early hours for fear of overpull. It is freely stated by some that overpull cannot be corrected, and persists if allowed to remain more than a very short time. This statement is erroneous. Overpull can be corrected readily, even if it has existed for several hours, provided it is corrected before the "congealing" of the musculature makes correction impossible. It is proper to say that it is difficult or impossible to correct if it has been in effect overnight, or if it has been applied *after* the muscle infiltration is advanced. Because of this misconception, overpull at any time is warned against. What is lost sight of is the fact that once the pathological state is fully established, underpull is as hard to correct as is overpull, and the too common conception of traction-suspension, skeletal or otherwise, as a method of *reduction* acting over days or weeks is responsible for some of the reputation which traction-suspension bears as a factor in the etiology of delayed union and non-union. As a method of *maintaining a reduction* it can of course be used for any period of time. Fractures seen twelve or more hours after injury are not ideal subjects for traction-suspension. For that matter, they are not ideal subjects for any method of treatment. It must be remembered that whatever method of reduction is used in these late cases must add additional pathology to get length, if the fracture site lies in muscle bellies already congealed. If traction-suspension is used in these cases, overpull must be carefully guarded against.

2. A fracture which is to have an open reduction is best done within four to eight hours after injury,—before the infiltration process has reached the point of being "fixed" in the tissues. During such an early operation the escape of blood and exudate from the tissues leads to minimal soft-part pathology with its functional implications, and, logically, on the basis of the conception of the healing process described above, to more certain and quicker calcification of the healing tissue to form callus. The author is firmly convinced by careful study of clinical results that this is actually so. He is also firmly convinced, on the basis of actual statistical analysis, that the risk of operative infection is less in these

early-hour operations than in those done at any other time within the first week after injury.

3. The least satisfactory time for open reduction on a recent fracture is from about the twelfth to the twenty-eighth day, during which time maximum decalcification of the bone in the vicinity of the fracture is occurring, and any internal fixation must be made in bone which may be incapable of taking the strain.

4. Recent fractures treated by open reduction followed by plaster immobilization take longer for bone healing than similar cases treated by closed methods. This clinical observation is thoroughly in keeping with the relative stagnation of the local minute circulation which results from immobilization of the soft parts as well as of the bone.

5. Early (emergency) operation, with internal fixation rigid and firm enough to allow of active mobilization postoperatively in counterbalanced *suspension, not only restores joint and muscle function more* promptly than is possible in immobilized patients, but promotes the speed and certainty of fracture healing. This it does by allowing the escape of a great deal of pathological material at operation, and by greatly increasing the effectiveness of the local minute circulation (tissue spaces, lymphatics, and ultimate capillaries) in dealing with what remains behind. The active functioning of muscles without spasm, such as can be obtained with properly applied and supervised balanced suspension after adequate operative fixation, is one of the most effective means at our disposal for the stimulation of such circulation.

6. In general the open reduction of fractures followed by plaster immobilization results in prolongation of the time needed for bone healing as compared with similar cases treated by closed methods. This is particularly true when the operation is done some days after healing. On the pathological process already "fixed" in the tissues, is superimposed the damage resulting from operative trauma, and the subsequent immobilization minimizes the efficiency of the local minute circulation which has to cope with the accumulation of products tending to defeat the adequate formation of callus. This has been the author's experience, and it could not logically be otherwise in the light of the strikingly definite findings under the preceding observation.

7. If examination of the roentgenograms leads to the conclusion that internal fixation, rigid enough to allow active mobilization of the extremity postoperatively in balanced suspension, will not be possible, the patient is best treated by closed methods if possible. This is but a natural corollary of observations 5 and 6. Operation on such a patient should be by virtue of necessity only. If he has to be operated upon, the earlier the operation the better, *provided* it is in the first two weeks.

8. If fixation is not rigid, and if it does not provide protection against torsional, sheering, and angular forces, absorption of bone about the fixation material will occur. When external immobilization of the extremity is added to the internal fixation of the fracture, these forces may

be guarded against in part or almost in whole at the expense of functional activity of the part, with all its implications.

9. On the basis of some of the points mentioned above, it is obvious that the principles of "reduction as soon after injury as possible" is applicable to *all methods of reduction.* It is questionable, however, as to whether or not this general rule holds true for fractures so situated that the question of progressive pathological change in muscle is not a factor, such as fractures involving the ankle joint (particularly when the inferior tibiofibular joint has been disrupted), fractures involving the wrist joint, and fractures of the os calcis. While it is unquestionably true that these fractures are best reduced within the first six to eight hours, it is also true that if they are first seen twelve or twenty-four hours after injury with enormous swelling (with or without bleb formation), not only is reduction at that time difficult, but adequate fixation in plaster is either difficult or impossible because of the tremendous soft-part swelling. Since no pathological condition exists in the muscles in these cases, with the exception of muscle spasm as a protective mechanism, is it not justified to devote twenty-four or forty-eight hours, not more, to an intensive attack on the soft-part swelling, so that reduction is more easily accomplished, more accurately gauged, and more readily and effectively maintained by external immobilization? Through the use of moderate elevation, constant low-grade heat, gentle stroking massage, the use of the positive and negative pressure boot, and such other methods as are at our disposal, the minute circulation can be speeded up and the tissue infiltration decreased. This is a far cry from "waiting for the swelling to go down" since it is actually an intensive attempt to disperse the tissue infiltration. It is getting rid of pathology, instead of allowing it to organize in the tissues. In this respect, and in the fact that such delay in reduction for a very limited time is applicable only to late cases with the pathology already established, and in which muscle is not involved in the pathological condition, it differs materially from John Royal Moore's delayed reduction practice.

10. Fractures involving certain portions of the body have been noted for their tendency to either excessive callus formation or actual ossification in the adjacent soft parts. This tendency is, of course, particularly marked in fractures, with or without dislocation, in which the anterior portion of the elbow joint capsule and the overlying brachialis anticus have been involved. This tendency can be prognosticated in many cases by the clinical examination which discloses signs of damage to the deep anterior structures with infiltration of the antecubital region, tension beneath the forearm fascia, and even direct antecubital ecchymosis within an hour or two of fracture, and by the anterior displacement of separated bone fragments. The abnormal bone formation occurs only if the pathological process is allowed to progress to its maximum. Operative or vigorous manipulative procedures after this time are apt to increase the tendency to bone formation. Relief of the soft-part pathology

in the early hours is the safeguard against this complication, whether it be accomplished by operation or otherwise. But recognition of the necessity for that relief is the crux of the situation.

It is the author's belief that our undergraduates can derive more sound understanding of the basic principles which underlie fracture treatment as a whole, if they come to think more about what any method of treatment has to accomplish in the guiding of the pathological process after fracture, and less about the technical details of treatment methods. The ability to interpret physical signs as indicative of the pathological state present, and of the speed with which it is progressing is a sound basis for the intelligent use of any method of treatment.

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PHYSIOLOGICAL SCOLIOSIS *

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This introductory study of the pathology and the therapy of scoliosis was undertaken in the hope that the results obtained would also be of definite value in the treatment of paralytic scoliosis. It was carried out in the Orthopaedic Department of the State University of Iowa, and the author gratefully acknowledges the interest and support accorded him by Dr. Arthur Steindler, the Head of this Department.

Prior to its recognition by anatomists and other investigators, the existence of physiological scoliosis had been constantly observed by tailors and dressmakers for many centuries, of course without their having recognized the condition. As the physiological scoliosis increased with advancing age, the tailor or dressmaker would become suddenly aware that the shoulders of the customer were no longer level and that one of the hips had become prominent. The whole stature of the individual had changed, and it would become necessary to camouflage the usual physiological deformation ascribed to age. The main reason for the change was nothing but physiological scoliosis, which, by shifting of the shoulder girdle from one side of the hip line to the other, had finally changed the stature.

The existence of physiological scoliosis was scientifically established over 150 years ago by Sabatier, who found that the great majority of adult spines showed a well-defined curve to the side; in the lumbar and cervicothoracic segments the convexity was usually to the left side, and in the thoracic region, to the right side.

The investigation of physiological scoliosis in cadavera and in living persons in large-scale clinical examinations has been mainly concerned with the lateral curve; the form of the curve and the direction of the convexity have been amply described. Most investigators agree upon the existence of the phenomenon, but some of prominence (notably Lorenz) deny it. In the author's opinion, the examination of cadavera or even of living persons can hardly prove or disprove the existence of physiological scoliosis. The reasons for this are obvious:

1. The position of the cadaver is always an arbitrary one, depending on the will of the investigator, especially in cases of *slight* abnormality.

2. In living persons the clinical investigation must take into account the to some extent arbitrary posture of the individual, his tendency toward autocorrection, and the difference in the length of the legs.

3. The routine roentgenographic examination is made with the

* Received for publication on August 12, 1940.

patient in the supine position; hence the author has found that the great majority of roentgenograms of the spine (especially of young persons), taken for other purposes, do not display much evidence of a lateral curve. It is well known that in cases of scoliosis slight lateral curves, and even more marked ones, completely disappear in the supine position.

4. In the standing position, lateral curves may be easily effaced by the counteraction of the *healthy* intervertebral discs, which, due to the large amount of their elasticity, do not allow the development of lateral curves for a long period, even in pathological scoliosis. Thus the demonstration of the spine without discs presents the lateral curves in an exaggerated form, as compared with the living individual, but it represents the deformation of the vertebrae in its true aspect.

In previous papers the author has repeatedly referred to the well-defined *deformations found in normal vertebrae, as well as to the cause* of these phenomena, but he has not included a detailed analysis. For this purpose, in the present study twenty complete normal skeletons, ranging from nineteen to eighty-six years of age, were examined. Besides these, the skeleton of a normal six-year-old child and that of a seriously deformed scoliotic child were examined and measured, serving as standard types of normality and scoliotic deformation with which the skeletons of normal adults were compared.

The examinations were concerned exclusively with the invariable element of the spine,—that is, with the vertebrae. The postmortem shrinking and the preparation of the ligamentous apparatus interfere with the true happenings, and the author tried to avoid any arbitrary factor in the investigations.

The examination of the cervical spine was omitted, as in this region scoliosis very rarely occurs. For mechanical and developmental reasons not to be discussed here, the author divided the spine into three functional segments:

I: The upper thoracic, comprising the first six thoracic vertebrae;

II: The lower thoracic, consisting of the remaining six thoracic vertebrae plus the first lumbar vertebra;

III: The lumbar, including the lower four lumbar vertebrae.

The twelve thoracic and the five lumbar vertebrae were examined with reference to the following factors:

1. The alignment of the spine when hung on a wire;
2. The height of the vertebral body on its left and right sides, measured at the level anterior to the attachments of the ribs and the roots of the pedicles;
3. The length of the pedicles (the distance between the posterior edge of the vertebra and the superior articular process);
4. The greatest width of the dorsal surface of the pedicles;
5. The length of the dorsal surface of the vertebral body on its right and left sides (the distance of the posterior border of the body from its anterior border);

6. The angle between the impressio eordalis vertebrae * and the spinous process on each side;

7. The angle between the impressio cordalis vertebrae and the transverse process on each side;

8. The angle between the impressio eordalis vertebrae and the inferior artieular processes of the lumbar vertebrae and of the eleventh and twelfth thoracie vertebrae.

The measurements were made by means of an anthropometer and a goniometer (Fig. 1).† The ehoiee of the mold on the back of the vertebral body (impressio eordalis) as the eenter for the measurements of the angles was motivated by the fact that it is the spinal eord which preserves its position best in any deformation of the vertebrae. In the ease of the spinous and transverse processes, the eenter of measurement was the end of the process. On the basis of the measurements, graphs, representing the behavior of the seventeen vertebrae measured, were drawn.

TERMINOLOGY

In order to avoid confusion, the author wishes to clarify the following terminology used in this paper:

1. *Neutral vertebrae* are those which do not show any obvious signs of deformation, having the normal shape eustomarily depicted in the textbooks of anatomy. They are ealled "neutral" instead of "normal" because either below them or above them, or both below them and above them the vertebrae are deformed. Thus they belong neither to the one class nor to the other class of deformed vertebrae within a deformed spine.

2. *Rhombic, lozenge-shaped, or transitional vertebrae* are those which have a eonspicuous rhombie shape, but show little or no difference in height between their right and left sides. They give the impression that the upper surface of the vertebral body has shifted to one side, while the lower surface of the

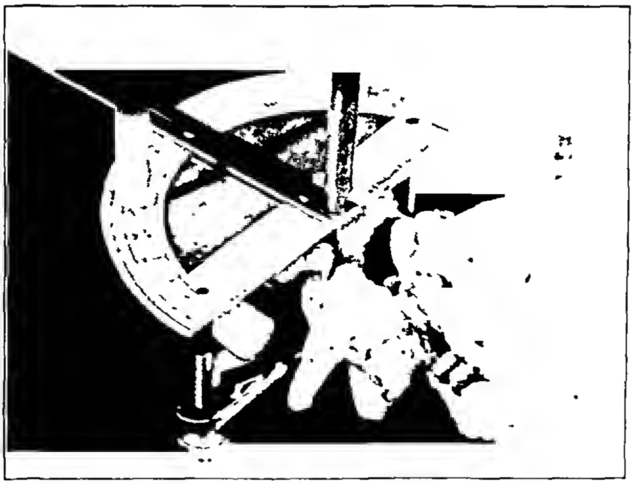


FIG. 1

Device for the measurement of the angles between the vertebral body and the spinous process, the transverse process, and the inferior articular processes.

* Posterior frontal surface of the vertebral body, the eenter of which is formed by the impression of the spinal cord.

† These instruments were designed by the author and constructed by Mr. A. P. Freund of the Physiology and Pharmacology Shop of the University.

same vertebrae has shifted to the opposite side. They connect one lateral curve, convex to one side, with another lateral curve, convex to the opposite side. Thus they represent a transitional zone in the course of changing curves.

3. *Wedge-shaped vertebrae* are those whose most striking feature is the diminishing of the height of the vertebral body on one side as though the vertebra had collapsed on one side, leaving the impression of a wedge. Wedging is the typical trait of the pathological scoliotic vertebrae in the center of the curve. Wedge-shaped vertebrae often are also rhombic to some extent, a phenomenon which has an important bearing on the development of scoliosis.

4. The *angles* represent the relationship between the sagittal plane and the frontal plane of the body. The perfectly normal spinous processes are in the sagittal plane, forming an angle of 90 degrees with the posterior surface of the vertebral body. The normal transverse processes of the middle thoracic region form an angle of 45 degrees with the posterior surface of the vertebral body. The normal inferior articular processes of the lumbar vertebrae form an angle of about 55 degrees with the posterior surface of the vertebral body.

5. The *elongation* is the lengthening of the upper surface of the right or left sides of the vertebral body; mechanically it is identical with the rhombic deformation. The rhombic deformation consists of the shifting of the entire upper surface of the vertebral body, while the elongation is the pulling out of only one side of the upper surface.

POSTNATAL DEVELOPMENT OF THE VERTEBRAE

Skeleton of Normal Six-Year-Old Child

At the age of six, the alignment of the spine was found perfectly straight; the physiological sagittal curves were completely developed. The vertebral bodies showed in all segments symmetric conditions. The height of the vertebral bodies was roughly the same on both sides, and there was no difference in the length of the upper surfaces of the vertebral bodies between the two sides. The asymmetric development of the pedicles in both dimensions had already started in Segment III.

The spinous processes were found exactly in the sagittal plane of the vertebral bodies, forming an angle of 90 degrees. The average value of the angle formed by the transverse processes in Segment I was 44 degrees, just 1 degree below the average found in adults. In Segment II the mean value of the angle formed by the transverse processes was 45 degrees; the transverse processes were perfectly symmetric on both sides. In Segment III the angle formed by the transverse processes was 29 degrees on the right side and 28 degrees on the left.

Skeleton of Severely Deformed Scoliotic Child

Examination of the other standard type—severe "habitual" scoliosis—showed the curves in the upper thoracic and lumbar segments convex

to the left; in the lower thoracic segment the curve was convex to the right (Fig. 2).

Every true scoliotic spine is composed of three kinds of vertebrae: *wedge-shaped*, *rhombic* (*lozenge-shaped or transitional*), and *neutral*. The wedging plays the chief rôle in the production of the lateral curve, and is regarded as the principal feature of this deformation. In the opinion of the author, the pathological scoliotic deformation begins with the formation of lozenge-shaped vertebrae (*prescoliotic stage*), and the lateral wedging follows later. This can easily be demonstrated in the further development of pathological curves. The lozenge-shaped vertebrae connect one curve with the other, and they are the vertebrae which become involved in the scoliotic process while the deformation progresses. Later on, the newly involved lozenge-shaped vertebrae tilt and gradually become wedge-shaped. Therefore, in any scoliosis, except perhaps in the case of the most wedge-shaped vertebrae, the original rhombic character always can be deduced from the marked oblique course of the bone lamellae. The scoliotic curves are generally regarded as lateral curves. This seems to be a mistake to some extent. *There is no pure lateral curve in pathological scoliosis.* Perfect lateral curves are found in the rare cases of *contracture of the spine*, especially following infantile paralysis. The pathological scoliotic curves are not lateral curves, but take place between frontal and sagittal planes; they collapse in the oblique plane, representing a diagonal deformation of the spine.

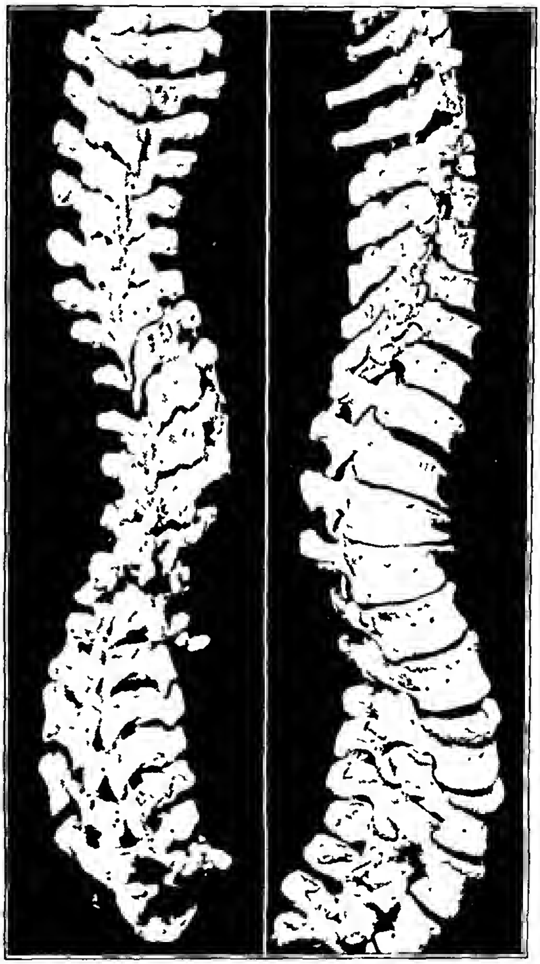


FIG. 2

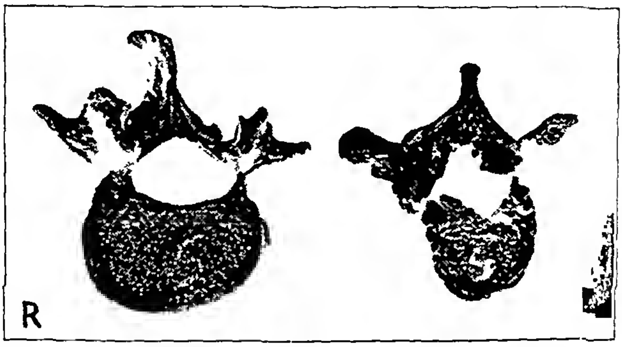
Spine of a scoliotic individual, showing collapse in the diagonal plane. The thoracic kyphosis has disappeared, and the lumbar lordosis has increased, due, in part, to subluxation of the articular processes. Many of the vertebrae have preserved their original rhombic (lozenge-shaped) form.

Another important point in pathological scoliosis is the behavior of the physiological sagittal curves. The com-

plete disappearance of the thoracic kyphosis and its replacement by lordosis (Fig. 2) are commonly observed. On the other hand, the lumbar lordosis, which, at the beginning of the process, especially in the "habitual" cases, frequently diminishes or disappears, becomes very often more marked in the course of the deformation, than in normal individuals.

The neural arches can resist the deforming forces much longer than the vertebral body, the latter being the first to be affected by the force of gravitation as well as by the pathological process leading to the deformity. That is why the spinous and transverse processes not only slowly follow

CONCAVITY



CONVEXITY

FIG. 3

Lozenge-shaped (transitional) vertebrae of a scoliotic spine. There is marked elongation to the right. The arches are definitely in the concavity of the curve, while the body has penetrated into the convexity.

the course of deformation but *remain definitely in the concavity throughout life* (Fig. 3). That is also why the vertebrae give the impression of rotation or torsion. In the author's opinion, there is very little true rotation of the thoracic vertebrae, even in pathological scoliosis; there is, rather, the delusion of rotation. The impression of rotation seems to be due simply to the fact that the bodies of the vertebrae have deviated to a much greater extent than have the neural arches. The resistance of the arches accounts also for the fact that the scoliotic deformation appears surprisingly less marked when the spinous processes are seen from the rear than when the vertebral bodies are viewed from the front. *Especially in the most important segment, Segment II, the deviation of the spinous processes was definitely opposite to that of the curve.* The transverse processes showed a great conformity in amount of, as well as in direction of, the deviation of the spinous processes. The pedicles behaved in all of the segments as they do in physiological scoliosis.

The deformation of the ribs seems to play but a minor rôle in physiological scoliosis; therefore, the discussion of this point is omitted here.

Skeletons of Twenty Normal Adults

In the twenty normal skeletons examined, there were no fundamental qualitative differences either between the age groups or between the sexes. It was noted that the amount of the lateral curves, the asymmetric

changes, and the osteophyte production increased with advancing age, although this seemed to be less marked in some instances than might have been expected.

Lateral Curves: In 80 per cent. of the specimens, the lateral curves were convex to the left in Segments I and III and to the right in Segment II. The number of vertebrae involved varied greatly in each specimen and in each curve, as compared with the others, and so did the amount of the curves. In some instances, very small lumbar curves were followed by sharp low-thoracic curves; in others the high-thoracic curve seemed to be effaced as compared with the other curves of the same specimen and with those of other specimens. In a few instances, only one long, sharp, low-thoracic curve was definitely present, while the lumbar and high-thoracic curves were only very slightly suggested. In the author's opinion, the percentage evaluation should be omitted, as the small series of only twenty specimens does not give sufficient evidence. In 20 per cent. of the specimens, an *inversion* of the lateral curves occurred. In these the lumbar and high-thoracic curves were convex to the right and the low-thoracic curve was convex to the left.

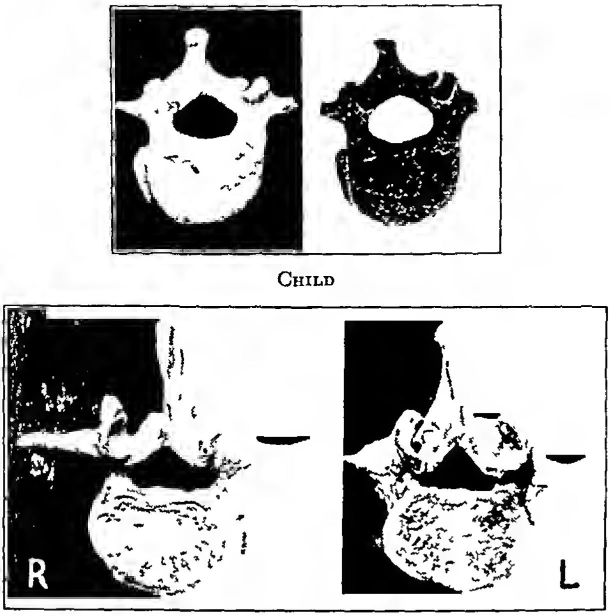
Elongation: Both the upper and the lower surfaces of the vertebral bodies became longer, pulled out on one side (Figs. 4-A, 4-B, and 4-C). In each specimen only a few vertebrae—most frequently in the high-thoracic and low-lumbar regions—failed to show this asymmetry. Generally, in the high-thoracic segment the vertebral bodies became elongated on the left side; in the low-thoracic segment, on the right side; and in the lumbar segment, on the left side. Exceptions to this rule were found in vertebrae belonging to spines which showed reverse curves (20 per cent. of the specimens).

Lateral Wedging: The further asymmetry consisted of the differences in height of the vertebrae between the right and left sides. This phenomenon, called "lateral wedging", revealed a very peculiar feature. In Segment I, none of the specimens showed vertebrae which were higher on the right side. In Segment II, only 15 per cent. of the vertebrae revealed a higher right side; 25 per cent. were higher on the left side; and 60 per cent. were level. In Segment III, 15 per cent. of the vertebrae were higher on the left side; 50 per cent. were higher on the right side; and 35 per cent. were level.

It was striking that in the most important segment, Segment II, more than half of the vertebrae showed no wedging; furthermore, almost twice as many of the vertebrae showed a greater height on the left side than on the right. This means that, in consideration of the fact that Segment II showed in 80 per cent. of the vertebrae a lateral curve convex to the right, in physiological scoliosis *the wedging has but little to do with the lateral curve;* otherwise, in 80 per cent. of the vertebrae the height of the vertebrae should have been found greater on the right side.

The contrasting behavior of the side of wedging and elongation on the one hand and the corresponding behavior of the side of elongation and

convexity of the curve on the other clearly demonstrate that *in physiological scoliosis the lateral curve is more intimately related to the elongation than to the wedging*, which is essentially opposite in the case of pathological scoliosis. As already pointed out, the chief feature of pathological scoliosis is that the height of the vertebral body on the convexity of the curve always exceeds that on the concavity, being exclusively responsible for the side to which the curve points.

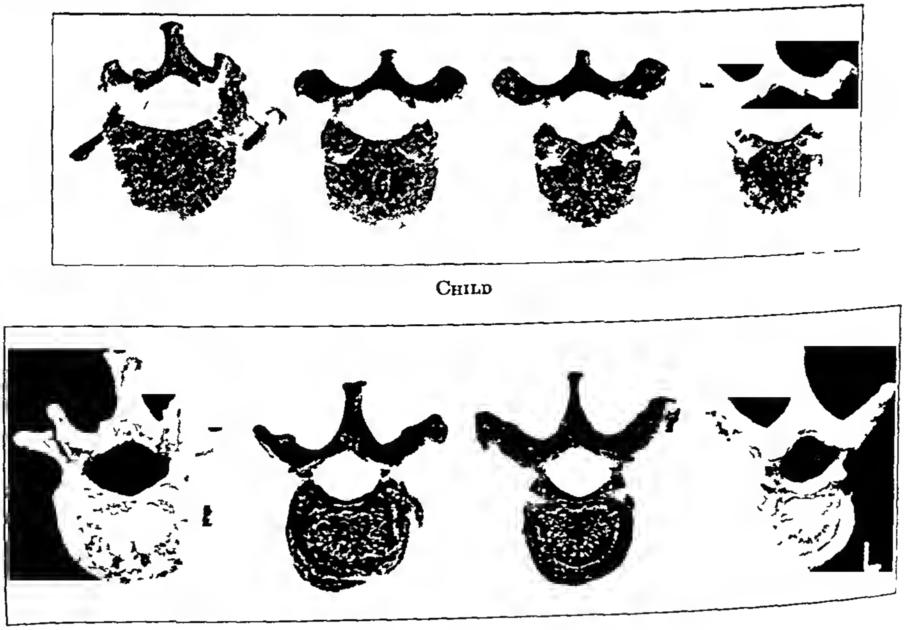


Child

Adult

Fig 4-A

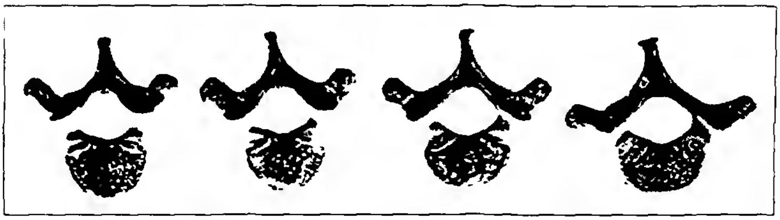
Pedicles: None of the parts of the vertebra disclosed the asymmetric postnatal development to such an extent as did the pedicles (Fig 5). The asymmetry can be noticed at the age of six, as already mentioned. The pedicle is the most sensitive segment of the vertebra, connecting as it does the vertebral body with the neural arch. Thus the pedicles, thin and relatively long, readily give evidence of the distort-



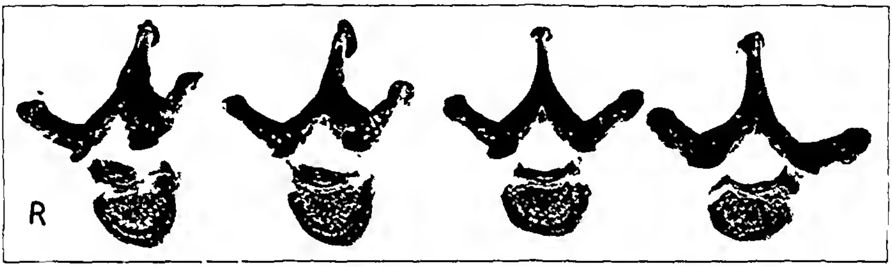
Child

Adult

Fig. 4-B



CHILD



ADULT

FIG. 4-C

Vertebrae of a normal six-year-old child compared with those of a normal adult.
Fig. 4-A: Lumbar segment; elongation to left in adult.
Fig. 4-B: Lower thoracic segment; elongation to right in adult.
Fig. 4-C: Upper thoracic segment; elongation to left in adult.

ing forces. They become asymmetric earlier than the bulky vertebral bodies or the resistant neural arches. None of the pedicles were found without asymmetry after the age of six. Either their length or their width, but in most instances both, showed the physiological deformation. The variation in the length of the pedicles showed a greater regularity than that in their width. In most instances the width of the pedicles was in inverse relation to their length: they were long and thin or short and broad.

Spinous Processes: In Segment I the spinous processes deviated to the right side in the majority of the specimens; in Segment II they pointed to the left; and in Segment III they generally deviated to the right. The deviation of the spinous processes was frequently twofold: their roots pointed to one side, while their extremities pointed to the other side, or formed an angle of 90 degrees.

Transverse Processes: The behavior of the transverse processes differed greatly from that of the spinous processes. In Segment I they generally deviated to the left; in Segment II half pointed to the right and the other half to the left; and in Segment III the great majority deviated to the left.

An almost complete conformity was found between the behavior of the transverse processes and that of the inferior articular processes.

As to the angles between the transverse processes and the posterior surface of the vertebral body, in Segment I they amounted to 45 degrees at the age of six, and from then on they showed a marked regression to the

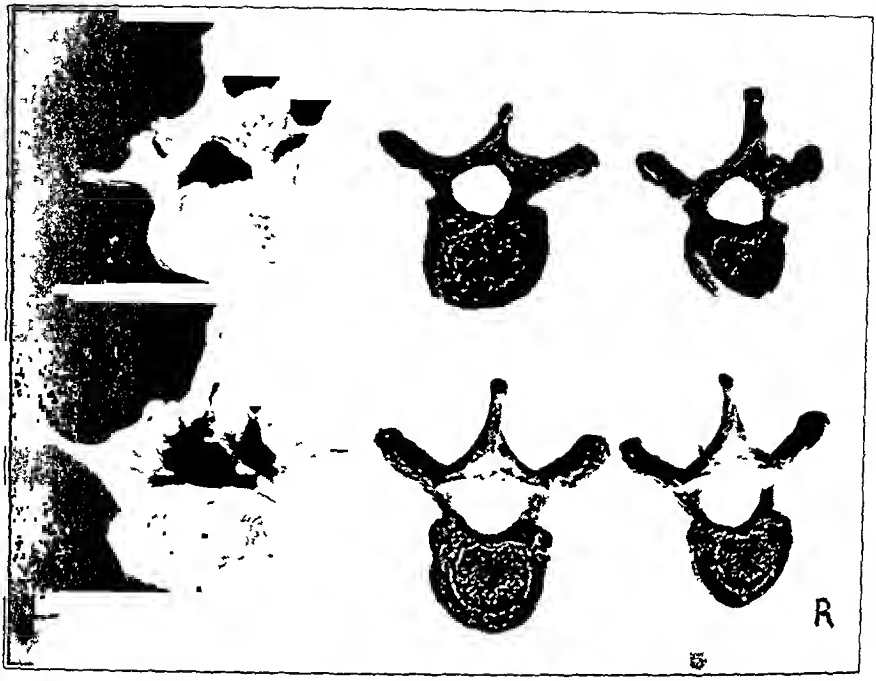


FIG. 5

Physiological deformation of the articular, spinous, and transverse processes and of the pedicles in a normal adult (lower row) as compared with similar deformity in a child with scoliosis (top).

mean value of 40 degrees in adults. In Segment II the 45-degree angle the age of six seemed to be maintained throughout life. In Segment I the 28-degree angle at the age of six diminished to 26 degrees in the adult The diminishment of the angles of the transverse processes was certainl caused by the development of physiological lordosis.

Ribs: The ribs were apparently of nearly the same shape and had th same angular value on both sides, in spite of the sometimes marked latera curves of the spine.

COMMENT

The question arose whether or not the findings were due to: (1) th normal variation of the spine or (2) the normal postnatal development As to the former, such a regularity of variation was found in all of the speci mens examined, that it seemed obvious that a variation occurring alway in the same or almost in the same way is no mere oscillation around a nor mal type, but it represents the normal features of the organ. As far as the question of the postnatal development determined by the germ is concerned, the fact that the vertebrae develop from symmetric ossification centers must be taken into account. There is no reason at all to assume that the two halves may develop in postnatal life in such a peculiar asym metric manner. The vertebrae of the six-year-old child, although com pletely developed, were almost perfectly symmetric. The *osteophyte* production, intimately connected with the asymmetric behavior of the vertebrae, as will be demonstrated later, is the best argument for the as-

TABLE I

MEAN VALUES OF VERTEBRAL BODIES AND PEDICLES (IN MILLIMETERS) COMPUTED FROM TWENTY DIAGRAMS

Spinal Segment	Vertebral Body				Pedicles			
	Height (Wedging)		Length (Elongation)		Length		Width	
	Right	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*
I	17 8	18 0	21 8	22 7	11 0	9 6	6 0	5 6
II	21 7	21 9	32 0	30 0	13 3	12 6	6 5	6 3
III	25.5	26 0	32 3	32 4	10 5	9 7	10 0	11 2

sumption that *the postnatal regular asymmetric development of the human spine is due to some powerful, automatic function which becomes established just prior to the age of six.* The question of whether or not the phenomenon could be regarded as the consequence of the asymmetric course of the aorta which flattens the vertebrae on one side must be considered also. The beginning of the descending portion of the aorta is the lower border of the fourth thoracic vertebra, somewhat to the left. Its termination is in the mid-line of the lower border of the twelfth thoracic vertebra. However, the changes in the vertebral bodies concern the entire spinal column. The upper thoracic region, as well as the lumbar region, reveals the most impressive asymmetric changes just where the descending aorta is in no relation to the spine (upper thoracic and lumbar vertebrae) or has already reached the mid-line of the spine (lower thoracic vertebrae). Thus, *physiological scoliosis is a postnatal development, due neither to the regular variation of the normal, nor to the innate formative energy of the cells,*

TABLE II

MEAN VALUES OF ANGLES (IN DEGREES) COMPUTED FROM TWENTY DIAGRAMS

Spinal Segment	Angles					
	Spinous Processes and Vertebral Body		Transverse Processes and Vertebral Body		Articular Processes and Vertebral Body	
	Right	*Left*	*Right*	*Left*	*Right*	*Left*
I	88 0	92 0	40.5	38 5		
II	91 0	89 0	45.0	42.0		
III	90 0	90 0	26 0	26.0	55.0	53.0

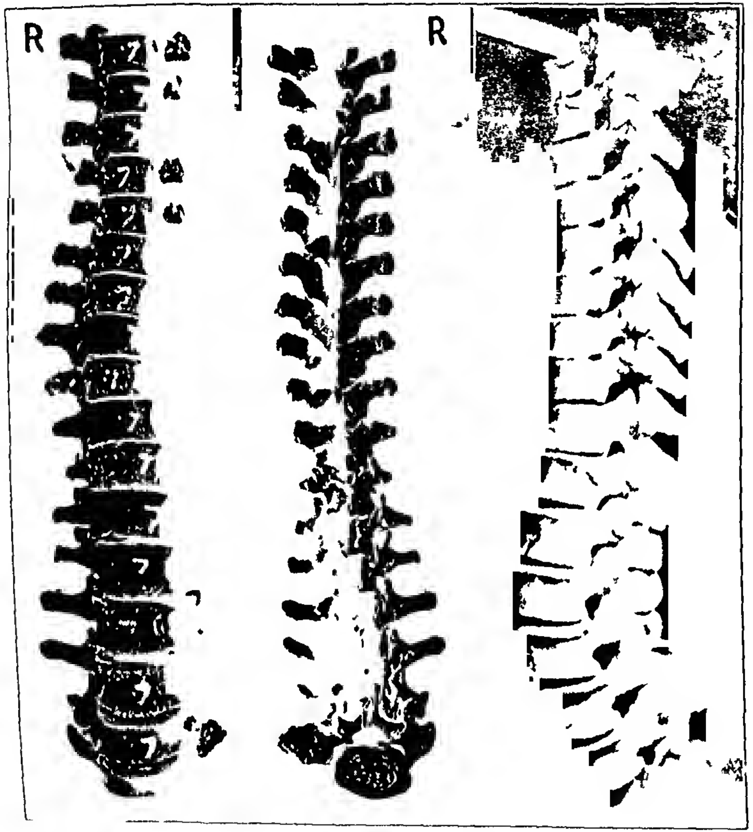


FIG. 6-A

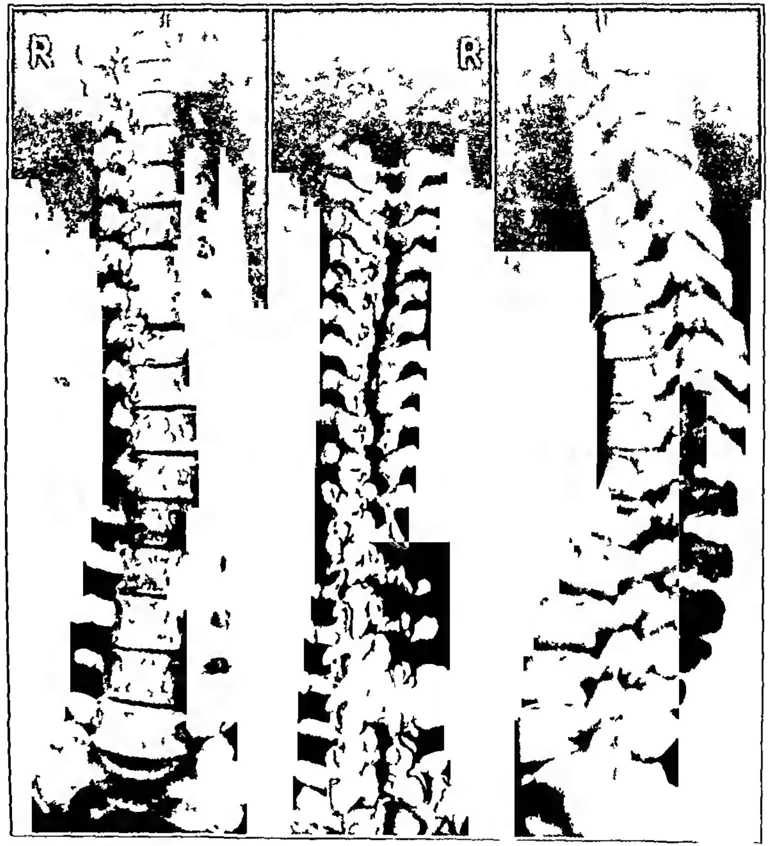


FIG. 6-B

Skeletons of normal adults. Most of the vertebrae are lozenge-shaped, forming a curve.

Fig. 6-A. Specimen 7. Very slight lumbar curve convex to left, marked thoracic curve to right (fifth thoracic to first lumbar), slight upper thoracic curve to left.

Fig. 6-B. Specimen 95. Lumbar curve to left (twelfth thoracic to fifth lumbar); lower thoracic curve to right (fifth to eleventh thoracic), upper thoracic curve to left. The physiological sagittal curves have been preserved.

nor to the proximity of another organ, such as the descending aorta, but is caused by a function continuously at work.

The author reviewed about one hundred spines, and none of them were without a more or less marked lateral curve. Thus there seems to be no doubt about the significance of the asymmetric development of the vertebrae. Most of the asymmetric changes discussed follow a rule, are intimately connected with one another, and represent nothing but the physiological lateral curve of the spine,—that is, they are features of the same phenomenon of physiological scoliosis. The curves themselves showed marked differences in degree, as well as in course. As will be demonstrated, the human gait as the cause of physiological scoliosis plays a definite part. Thus the asymmetric features of the spine are influenced by special etiological factors. Most of the curves were multiple. *The most important finding was that in each specimen the functional Segment II was involved in the formation of the curves.*

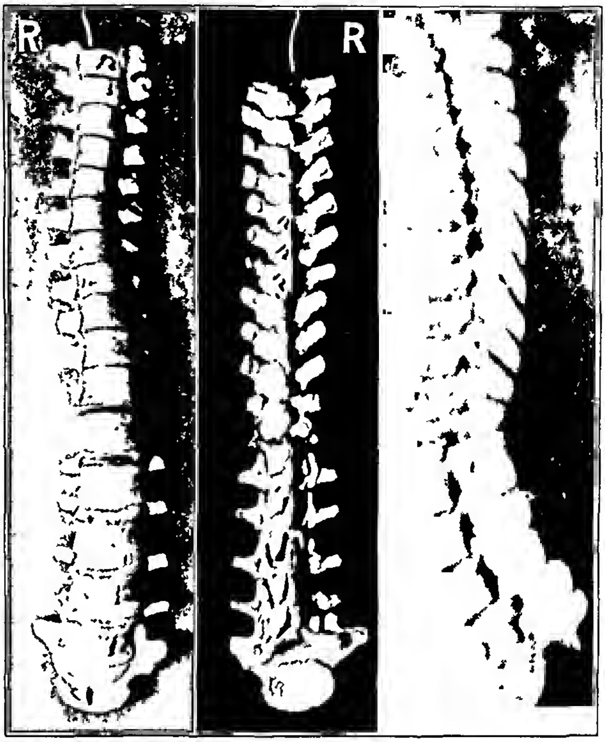


FIG. 6-C

Specimen 12. Lumbar curve to left; lower thoracic curve to right (fourth to twelfth thoracic); upper thoracic curve to left.

On the basis of the investigation, the characteristic features of physiological scoliosis were found to pertain to the following: (1) the lateral curve; (2) elongation of the vertebrae; (3) the spinous processes; (4) the physiological sagittal curves; and (5) the ribs.

Lateral Curve

From the rear, the lateral curve appears much less marked than from the front (Figs. 6-A, 6-B, and 6-C). That is why some of the well-known investigators, such as Lorenz, denied for a long time the existence of physiological scoliosis.

Elongation

Elongation is the most striking asymmetric feature of normal vertebrae, and there is no doubt whatsoever that physiological scoliosis is chiefly due to elongation (Table I).

In Segment II, the elongation was on the right side in 80 per cent. of the specimens. In only 20 per cent., was the elongation on the left. In the latter the lumbar curve and a slight high-thoracic curve pointed to the right. In 10 per cent., the low-thoracic segment formed the lower end of the high-thoracic curve, which pointed to the left. It should be stressed that, *except for the specimens with inverted curves, in all specimens the low thoracic vertebrae showed an elongation to the right.*

Mechanically, the dorsoventral elongation is the gliding of the spine toward the side of the elongation anterolaterally, establishing the physio-

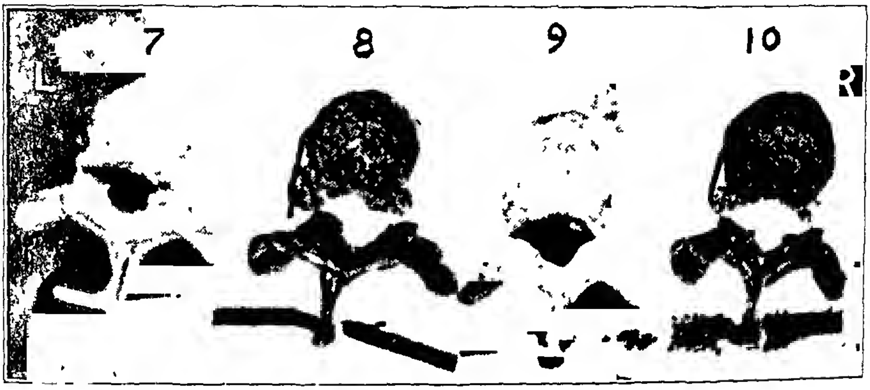


Fig. 7

Seventh, eighth, ninth, and tenth thoracic vertebrae of normal adult, showing elongation to right with deviation of the spinous processes to left as continuation of elongation toward the back. Note diagonal character of physiological scoliosis as well as osteophytes on the side of elongation.

logical scoliotic curve; morphologically, the dorsoventral elongation is the gliding of the spine in the diagonal plane. The vertebrae with marked elongation are, without exception, rhombic in shape; thus physiological scoliosis is built up exclusively of lozenge-shaped vertebrae. The elongation in the diagonal plane is a true scoliotic phenomenon and cannot be compensated for except by means of another curve with opposite convexity.

The physiological scoliosis formed by lozenge-shaped vertebrae represents the prescoliotic stage. The lozenge-shaped vertebrae of a true scoliotic spine show the same elongation which was found to be the important feature in physiological scoliosis (Figs. 4-C, 6-A, 6-B and 6-C). In the latter, however, no wedging occurs, as the normal spine is devoid of those pathological conditions which eventually bring about the collapse of the vertebrae. The latter will be described in detail in a forthcoming study.

In pathological scoliosis the lozenge-shaped vertebrae collapse on the side opposite the original elongation. In physiological scoliosis, in spite of curve and of gravitation, no collapse occurs. The spine remains "prescoliotic" throughout life.

The elongation not only occurs in the convexity of the curve, but

forms it. The anterolateral elongation demonstrates the way in which the spine has moved into the diagonal plane, forming the convexity of the curve. It is of great significance that this motion did not take place in the articulations of the articular processes, but was brought about by the formation of lozenge-shaped vertebrae. The articular processes did not show signs of articular motion. This is an important feature of the prescoliotic stage.

Spinous Processes

The spinous processes in the majority of the specimens were found pointing to the right in Segment I, to the left in Segment II, and to the right in Segment III. Since the vertebral bodies were longer on the left in Segment I, on the right in Segment II, and on the left in Segment III, the direction of elongation was generally opposite the direction of the spinous processes. Thus the spinous processes form the continuation of the elongation posterolaterally, establishing the diagonal character of the scoliotic deformation (Fig. 7). The deviation of the spinous processes is not due to wedging, even in true scoliosis; actually it is part of the original diagonal elongation forming the backward continuation of the lengthened vertebral body.

Physiological Sagittal Curves

The diminishing or disappearance of the kyphotic curve of the thoracic spine and the final increase in the lumbar lordosis comprise one of the chief signs of pathological scoliosis. Physiological scoliosis never shows this sign. The physiological sagittal curves are preserved in physiological scoliosis throughout life.

Ribs

Another important point is the difference in the behavior of the ribs. In spite of marked multiple lateral curves, the ribs showed very little difference between the two sides. This is a surprising fact, as one would have expected a deformation of the ribs consistent with the scoliotic curve.

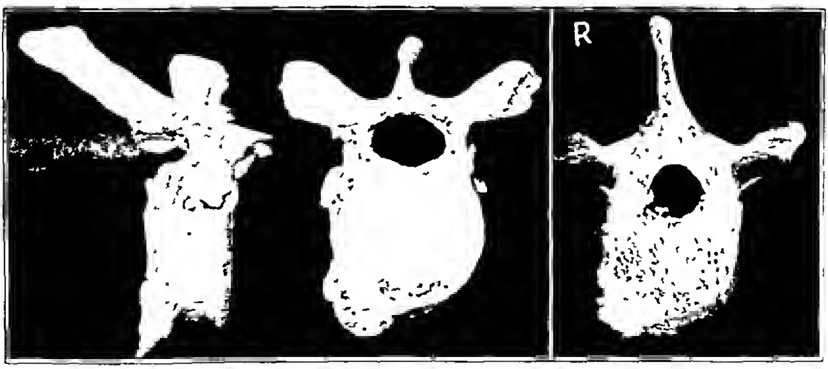


Fig. 8-A Fig. 8-B

Osteophytes start from the ring-like bony rim of the vertebral body as a continuation of the elongation.

Fig. 8-A: Photograph. Fig. 8-B: Roentgenogram.

As the wedging plays but a subordinate rôle in physiological scoliosis, the deformation of the ribs in true scoliosis must be chiefly bound up with the wedging of the vertebrae and with the process that caused it. Wedging and rib deformation, diagonal collapse of the spine, and prominence of the back in any position of the trunk seem to be correlated and subject to the same law. Since the wedging is brought about by that pathological condition which led to the collapse, by finding out the main cause of wedging, the chief pathological and mechanical factors of the pathological scoliotic deformation can be reached, as will be demonstrated in further papers.

OSTEOPHYTES

The first signs of osteophyte production could be detected at about the age of thirty years. Without exception, the osteophyte production started at the ventral edge of the elongation and spread out from there, sometimes extending over the entire circumference of the vertebra in advanced age (Figs. 7, 8-A, and 8-B). The osteophytes changed their site in accordance with the change of site of the elongation. As the elongation was to the left in Segments I and III and to the right in Segment II, the osteophytes were situated on the left side in Segments I and III and on the right ventral border of the vertebrae in Segment II. They always arose from the ring-like bony rim of the circumference of the vertebrac and did not start from the body as Schmorl claimed. Osteophyte production and elongation are due to the same mechanical manoeuvre,—namely, the gliding of the vertebrae on each other in the diagonal plane (Figs. 8-A and 8-B). The friction of the vertebrae against each other should be blamed for the osteophyte production which is a regular by-product of physiological scoliosis.

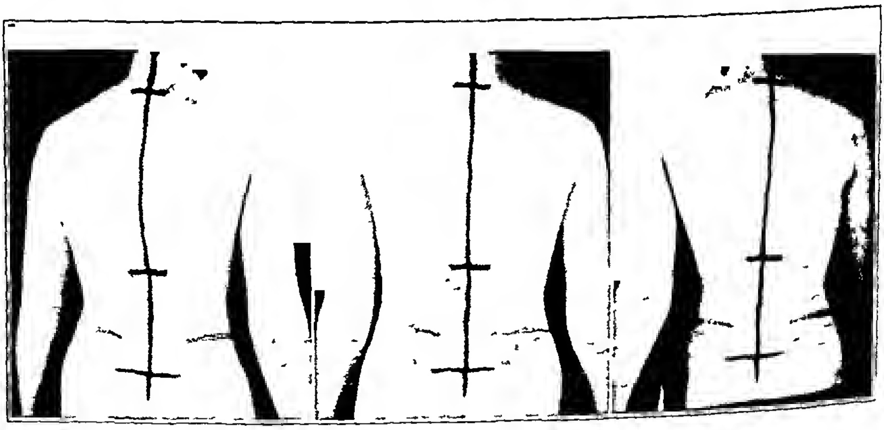


Fig. 9

Marked lateral curves of spine during gait taken by moving pictures. Oscillation of spine to side, depending upon the side of the swinging leg. (See also Figs. 10 and 11.)

Seven-year-old child examined on treadmill.

Left: Right leg swinging; lumbar spine curved to right, thoracic spine to left.

Center: Double support, spine straight.

Right: Left leg swinging; lumbar spine slightly curved to left, thoracic spine to right.

HUMAN GAIT AS CAUSE OF PHYSIOLOGICAL SCOLIOSIS

In order to find the reason for physiological scoliosis the following points should be taken into account:

1. All investigators agree that physiological scoliosis cannot be demonstrated prior to the age of six years. This means that the function which has provoked this phenomenon becomes established just before this age.

2. As no physiological scoliosis could be observed in animals, this condition is bound up with the erect position.

3. In situs inversus viscerum, the course of the scoliotic spine has been found opposite that of normal persons (Gaupp). Thus physiological scoliosis is intimately connected with the unequal distribution of the weight between the right and left sides of the body.

4. Physiological scoliosis becomes more marked with advancing years. Thus it is connected with a function which is continuously at work in the same manner throughout life.

5. Physiological scoliosis is a diagonal deformity of the spine, as is also pathological scoliosis. This means that the function leading to it must exert a deforming power in the diagonal plane of the body.

6. In the present investigation, no normal adult spine was found without a more or less marked scoliotic inclination. This statement implies the existence of an automatic function, but, as the resulting change is of asymmetric nature, the underlying function must be partly of asymmetric nature.

7. As no two spines were found with identical lateral curves, the function leading to the phenomenon is assumed to have marked individual features within a general law.

The only function which meets all of these requirements and is powerful enough to deform such a resistant system as the spinal column is the human gait. The gait becomes established in its perfect automatic manner at about the age of five years when the cerebellum "attains its full size" and exercises full control of the erect position (Gesell). The human gait is bound up with the erect position; it is highly influenced in its symmetry by the unequal distribution of the weight of the organs on the right and left sides; it is automatic; it takes place in most phases in the diagonal plane; it is highly individual; and, finally, it is powerful enough to change the symmetry of spine and vertebrae.

The investigation of the behavior of the spine during gait consisted of the invaluable gait coordinates of Otto Fischer, and of observations of several individuals made by the author by means of moving pictures.

The human gait consists of phases of lost and regained equilibrium. According to Steindler, "locomotion is a rhythmic play of muscle forces between loss and recovery of equilibrium". The three phases of human gait are: (1) standing; (2) swinging; and (3) a small period (double support) between the other two phases when both feet are on the ground. During the entire procedure the center of gravity rises and descends, and

As the wedging plays but a subordinate rôle in physiological scoliosis, the deformation of the ribs in true scoliosis must be chiefly bound up with the wedging of the vertebrae and with the process that caused it. Wedging and rib deformation, diagonal collapse of the spine, and prominence of the back in any position of the trunk seem to be correlated and subject to the same law. Since the wedging is brought about by that pathological condition which led to the collapse, by finding out the main cause of wedging, the chief pathological and mechanical factors of the pathological scoliotic deformation can be reached, as will be demonstrated in further papers.

OSTEOPHYTES

The first signs of osteophyte production could be detected at about the age of thirty years. Without exception, the osteophyte production started at the ventral edge of the elongation and spread out from there, sometimes extending over the entire circumference of the vertebra in advanced age (Figs. 7, 8-A, and 8-B). The osteophytes changed their site in accordance with the change of site of the elongation. As the elongation was to the left in Segments I and III and to the right in Segment II, the osteophytes were situated on the left side in Segments I and III and on the right ventral border of the vertebrae in Segment II. They always arose from the ring-like bony rim of the circumference of the vertebrae and did not start from the body as Schmorl claimed. Osteophyte production and elongation are due to the same mechanical manoeuvre,—namely, the gliding of the vertebrae on each other in the diagonal plane (Figs. 8-A and 8-B). The friction of the vertebrae against each other should be blamed for the osteophyte production which is a regular by-product of physiological scoliosis.

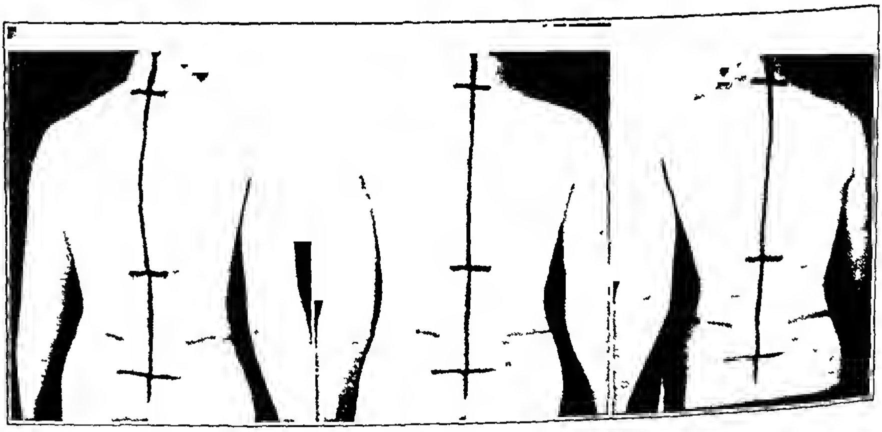


Fig. 9

Marked lateral curves of spine during gait taken by moving pictures. Oscillation of spine to side, depending upon the side of the swinging leg. (See also Figs. 10 and 11.)

Seven-year-old child examined on treadmill.

Left: Right leg swinging; lumbar spine curved to right, thoracic spine to left.

Center: Double support, spine straight.

Right: Left leg swinging; lumbar spine slightly curved to left, thoracic spine to right.

ment from left front toward right back. Thus, roughly, there result a lumbar and cervical curve convex to the left and a thoracic curve convex to the right. Then follows a phase when both feet hit the ground at the same time for a very short period. In this phase of double support, the body is nearly in the frontal plane. Then the right leg starts swinging and the same bending-rotating manoeuvre produces a spinal curve, in every respect opposite to the previous curves.

Here, however, innate asymmetries intervene. The heavier right side with its more powerful muscles performs movements which are equal in form but not in scope to those performed by the left side. Fischer found that the pressure which the right foot exerted on the ground while walking exceeded by nine pounds the pressure exerted by the left foot. An evaluation of the records of Plato Schwartz showed that the pressure of the right foot exceeded that of the left by about 2 per cent. Standing on two scales at the same time showed roughly from 5 to 25 per cent. higher pressure in favor of the right side. Thus the kinetic energy must sharpen the curves of the spine on one side of the body more than on the other side. It should be stressed that the formation of the most regular of the lateral curves—namely, that in Segment II—is essentially facilitated by the constant pull of the heart. The heart, like a hanging weight, moves the spine to the right side; it helps to establish and to maintain the deviation.

During the author's observations, for the purpose of moving pictures,

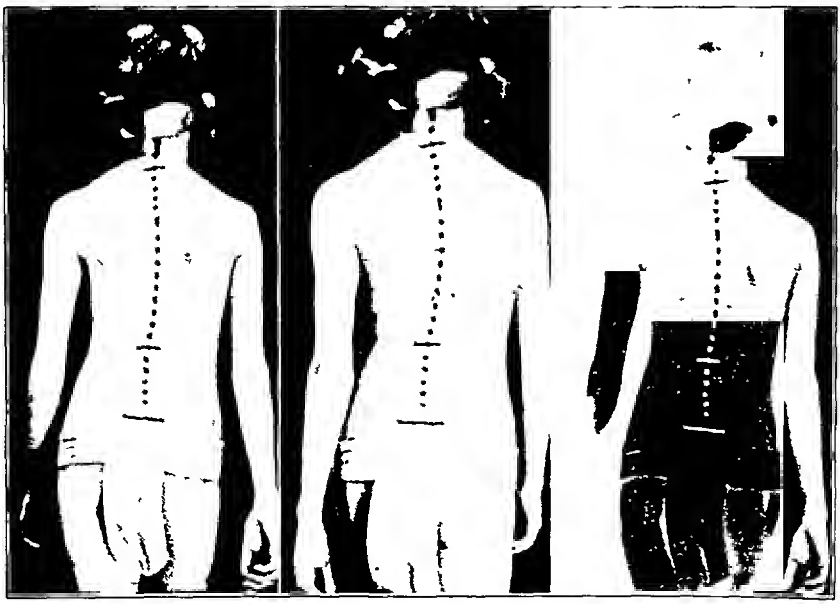


Fig. 11

Habitual scoliosis.

Left: Double support; lumbar curve to left, thoracic curve to right.
Center: Left leg swinging; scoliotic curves markedly increased.
Right: Right leg swinging; scoliotic curves markedly diminished.

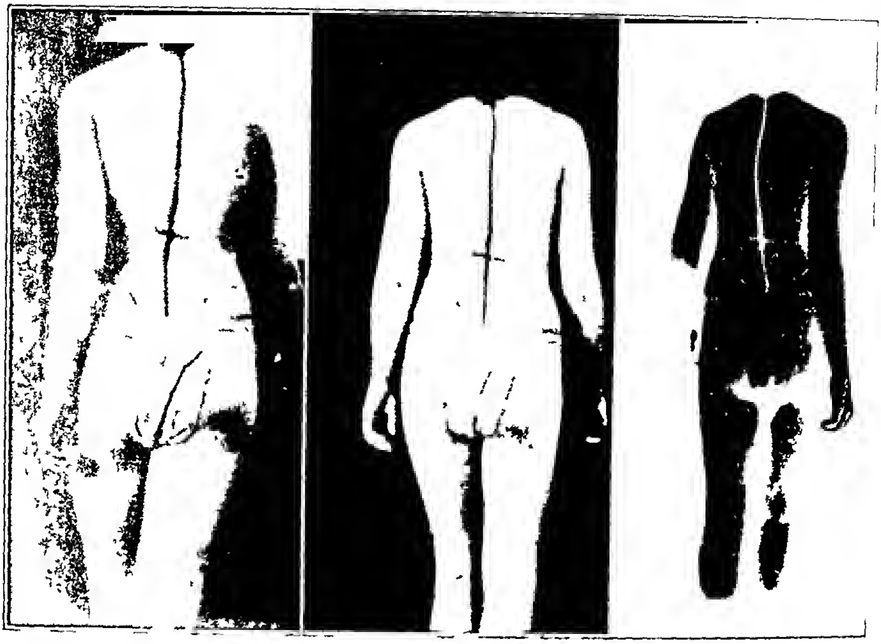


Fig. 10

Normal woman.

Left: Left leg swinging; lumbar spine curved to left, thoracic spine to right.
Center: Double support; straight spine.
Right: Right leg swinging; slight lumbar curve to right, long lumbothoracic curve to left.

tends to come as close as possible to the sagittal plane to prevent falling toward the side of the standing leg.

The evaluation of the coordinates of Fischer shows that the trunk is involved in highly complicated manoeuvres, consisting of rotation of the pelvis in one direction, rotation of the trunk and shoulder-girdle in the opposite direction, and the tendency to keep the head and eyes in the horizontal plane.

While the left leg swings, the pelvis becomes elevated on the left side, the palpating fingers feel the contraction of the sacrospinal muscles on the left side, and simultaneously the lumbar or lumbothoracic segment describes a curve convex to the left. At the same time the left edge of the pelvis rotates forward. The trunk is now in danger of bending and eventually of falling down to the right side. To prevent this, the right shoulder rotates forward, the lowered left shoulder rotates backward, and the trunk tries to bend over to the left side in order to bring the weight above the sagittal plane. This double manoeuvre—the rotation of the shoulders and the bending of the trunk—produces the second curve of the spine, a thoracic curve convex to the right. Then the head bends over to the right, producing a thoracocervical curve convex to the left.

All these manoeuvres are not brought about in the frontal plane; the entire supracoxal part of the body is in the diagonal plane, pointing in the lumbar segment from left front toward right back, in the lower thoracic segment from right front toward left back, and in the upper thoracic seg-

physiological and true scoliosis are as follows: In physiological scoliosis the physiological *sagittal* curves never disappear, and, furthermore, in none of the specimens examined were all of the bone elements of the same vertebra concerned at the same time; in true scoliosis all of the parts of the vertebra are more or less deformed.

5. The osteophyte production always starts at the ventral edge of the dorsoventral elongation.

6. In physiological scoliosis, as well as in pathological scoliosis, the deformation of the spine takes place in the diagonal plane, never in the exact frontal plane.

7. The cause of physiological scoliosis is the human gait, which forces the spine into a threefold curve, alternately changing at every step. However, the innate normal asymmetries of the human body eventually establish permanent lateral curves of the spine, showing marked individual variations within the general law.

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AN ANALYTICAL STUDY OF BONE AND JOINT LESIONS IN RELATION TO CHRONIC PULMONARY TUBERCULOSIS

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In this paper a study has been made of the tuberculous orthopaedic patients who entered the San Francisco Hospital in the Tuberculosis Service of the University of California from January 1920 to July 1935.

It is difficult to obtain a clear concept of the outcome of tuberculous bone and joint disease unless a complete analysis is made of a series of cases extending over a number of years. The high mortality which the authors encountered in a general tuberculosis hospital was so at variance with reports of the usual outcome of this form of tuberculosis, that it was thought of sufficient importance to analyze the cases.

Many studies of the end results have been reported in the literature, but these in greater part were based upon series of cases which were selected for conservative or surgical treatment, or a combination treatment. The low mortality and the apparently numerous successful results reported in these papers lead to the conclusion that bone and joint tuberculosis is particularly amenable to treatment.

Other studies, however, especially those of Cleveland [1], deal with the problem viewed in a broader manner. His findings show that the disease is serious, successful results are fewer, and the mortality is high. As is so well emphasized by Cleveland, the authors also feel that this latter type of survey, by not excluding any cases whatsoever, presents a much more typical cross section of the results of tuberculous joint infection. Admittedly, series such as these may overemphasize the poor results, since they include many patients who were in the terminal stage of far-advanced pulmonary tuberculosis, but, even so, the authors think the all-inclusive survey gives the more accurate picture of tuberculous joint disease.

Though constantly requiring re-emphasis, it is well known that tuberculous bone and joint infection is usually secondary to some primary tuberculous focus. The treatment of joint disease cannot be considered independently of the treatment of the general infection. Therefore, in the study of a large group of tuberculous patients with all manifestations of the disease, many pertinent facts which might be overlooked in the study of a selected series should come to light. Details thus revealed may be advantageously applied to the treatment of joint disease with the purpose of lowering mortality rates and increasing the number of good end results.

METHODS OF ANALYSIS

Cleveland's article appeared in the literature at the time these data were being collected. The authors are in accord with his proposal that a uniform classification of types or degrees of tuberculous disease is necessary for a basis of comparison in an end-result study. While an attempt has been made to follow his general plan rather than to use his classification, this series has been analyzed with especial reference to pulmonary disease, and the standard classification of the National Tuberculosis Association has been used.

DIAGNOSIS

The San Francisco Hospital is a municipal institution which admits all patients upon whom either a positive or tentative diagnosis of tuberculosis has been made. In most of the cases studied, the diagnosis was proved through confirmation in the laboratory and often by postmortem examination. For those whom it was not possible to reexamine there were sufficient data to classify the end results for this study.

Diagnosis, especially if the lungs were involved, was fairly obvious in advanced cases, but in the early cases it was often difficult or uncertain. Usually the diagnosis was made upon clinical, roentgenographic, and laboratory findings. Wherever possible, however, the diagnosis was substantiated by bacteriological examination, guinea-pig inoculation, and at autopsy.

TREATMENT

The program of treatment placed primary emphasis upon the systemic tuberculous infection, and secondarily concerned itself with the specific focal disease. The general regimen consisted of bed rest in the

TABLE I

NUMBER AND PERCENTAGES OF LESIONS IN PATIENTS WITH TUBERCULOUS BONE AND JOINT DISEASE

Classification	Total Patients		Total Lesions		Survivors				Non-Survivors			
					Patients		Lesions		Patients		Lesions	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Non-pulmonary..	42	26 3	53	26 1	26	31 3	29	28 1	16	20 8	24	24
Minimal.......	33	20 6	45	22.2	23	27.7	35	34 0	10	13 0	10	10
Moderately advanced..... ..	25	15 6	28	13 8	14	16 9	15	14 6	11	14 3	13	13
Far advanced. ..	60	37.5	77	37 9	20	24 1	24	23 3	40	51 9	53	53
Totals.........	160	100 0	203	100 0	83	100 0	103	100 0	77	100 0	100 0	100 0

TABLE II

REGIONAL DISTRIBUTION OF BONE AND JOINT TUBERCULOSIS IN 160 PATIENTS

Location	No.	Per Cent.
Spine	67	33.0
Hip	30	14.8
Fingers, toes, and long bones	22	10.8
Knee	17	8.4
Sacro-iliac	15	7.5
Sternum	8	3.9
Elbow	8	3.9
Ribs	7	3.4
Shoulder	7	3.4
Ankle	6	2.9
Wrist	4	2.0
Tarsus	4	2.0
Irregular bones, ilium, sacrum, mandible	5	2.5
Tendon, bursae	3	1.5
Total	203	100.0

open air, Rollier or light therapy, high-caloric diet, and some form of cod-liver oil.

Surgical procedures were only employed after a long period of conservative treatment. During this time, the usual orthopaedic measures of deformity prevention or correction, and joint immobilization were constantly in use.

Surgical methods included arthrodesis, eradication of focus by amputation, aspiration, or incision of abscesses. The latter treatment was practised only when skin perforation was imminent, or when a sinus was already present.

In this series the proportion of lesions treated surgically is admittedly small, eighty-five out of the 203 lesions, or 41.9 per cent. The reason for this was that some of the patients had been treated elsewhere, and a large number of the patients had moderately or far-advanced pulmonary lesions (See Table I).

ANALYSIS

Occurrence

Region Affected: The number of patients who entered the Service during these years was 4252; of these, 160 or 3.76 per cent. had bone and joint disease, but many had multiple lesions, thus bringing the number for statistical data up to 203. This study is based on the number of lesions, and not on the number of patients. It is of great interest that the 4 per cent. of bone and joint lesions in Cleveland's much larger series so closely approximated the percentage of the authors'. In other statistical studies as well, it may be seen that the greatest number of these lesions appeared in the spine and other weight-bearing joints (See Table II).

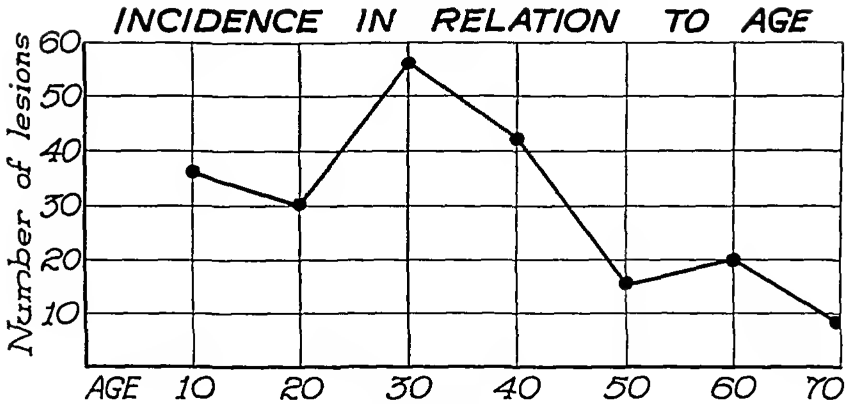

CHART I

The incidence in relation to age is based on 203 lesions, rather than 160 patients, because of the multiple lesions counted.

Age Incidence: The years from fifteen to thirty-five are designated as the period of greatest incidence of pulmonary tuberculosis. It is very striking, as shown in Chart I, that these are also the years in which tuberculous bone and joint lesions appear most frequently. The curve indicates that 164 or 81 per cent. of these lesions occurred in patients under the age of forty years. In many of the older patients the onset had been during the earlier years of life. This is an important fact and may be added evidence in support of the contention that this form of the disease is secondary to other tuberculous foci.

Race: Race has been recorded rather than nationality. On the Pacific coast there are a relatively great number of inhabitants belonging to the yellow and mixed races, and relatively few to the black. Racial classification is of importance since, as is well known, these peoples (yellow, mixed, and negro) have very little resistance to tuberculous infection.

Relation of Bone and Joint Tuberculous Lesions to the Various Stages of Pulmonary Disease

The incidence of bone and joint tuberculosis in the various groups, following the classification of the National Tuberculosis Association is shown in Table I.

In the first group of forty-two patients—those with no clinical evidence of pulmonary disease—there were thirty-four patients who had other manifestations of tuberculosis (forty-five lesions). These associated lesions were either multiple bone and joint involvement, abscesses, extensive tuberculosis of the genito-urinary tract, widespread tuberculosis of the skin, generalized tuberculous adenitis, polyorrhomenitis, and some, eventually miliary tuberculosis. Only eight patients had no other focus of disease.

Another important factor in this group pertains to the children. In the examinations of the roentgenograms of the twenty-four younger patients it was found that although no parenchymal lesion was discernible, twenty-one, or 87 per cent., showed evidence of either calcification or en-

TABLE III

END RESULT OF 203 TUBERCULOUS BONE AND JOINT LESIONS IN 83 SURVIVORS AND 77 NON-SURVIVORS

Location	Total Lesions	Lesions in 83 Survivors						Lesions in 77 Non-Survivors	
		Well		Improved		Unimproved			
		No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Spine	67	7	10	15	22	7	10	38	58
Hip	30	9	30	4	13	4	13	13	44
Fingers, toes, and long bones	22	4	18	3	14	5	23	10	45
Knee	17	3	18	5	29	2	12	7	41
Sacro-iliac	15	1	7	4	26	1	7	9	60
Sternum	8	0	0	1	12	2	25	5	63
Elbow	8	2	25	2	25	0	0	4	50
Ribs	7	2	29	1	14	1	14	3	43
Shoulder	7	0	0	1	14	0	0	6	85
Ankle	6	4	66	1	17	1	17	0	0
Wrist	4	1	25	0	0	2	50	1	25
Tarsus	4	1	25	1	25	0	0	2	50
Irregular bones	5	0	0	2	40	1	20	2	40
Tendon, bursae	3	1	33	2	67	0	0	0	0
Totals	203	35	17	42	21	26	13	100	49

largement of the hilum glands. It is possible only by frequent and careful examinations of the chest, including the roentgenograms, to ascertain pulmonary lesions associated with the joint disease; the search for these should be unremitting since these lesions bear such a great influence upon the outcome of the local lesions. This applies to both the adult and the child.

In the examination of the pulmonary group, comprising almost 74 per cent. of the cases and an equal per cent. of the lesions, the bone and joint complications were found to be greatest in the patients with far-advanced disease. This is to be expected, since it is in this stage that the greatest number of other complications occur, and is well proved by past experiences. In the minimal and moderately advanced groups, the bone and joint lesions occur less frequently than in the far-advanced group, as indicated in Table I.

End Results

A study of Table III reveals the rather startling and certainly discouraging fact from the orthopaedic standpoint, that only thirty-five, or 17 per cent., of the total number of lesions are recorded as well. Forty-two, or 21 per cent., were improved; twenty-six, or 13 per cent., unimproved; and 100, or 49 per cent., were in patients who have

died. At first glance it would appear that this is a most unusual series of tuberculous joints; on the contrary, the authors feel that it is not unusual since all the patients entering a large general tuberculosis hospital have been included.

Those who lived will first be considered, and then those who have died. From Table IV it may be seen that in the survivors, twenty-nine of the lesions were in the non-pulmonary group, thirty-five in the minimal, fifteen in the moderately advanced, and twenty-four in the far-advanced pulmonary group. The preponderance of lesions in the first two divisions with no or minimal lung involvement indicates that with increased pulmonary disease the local disease becomes more serious. This is also true when the outcome is considered from the standpoint of the patient rather than the lesion.

In the far-advanced group it is of importance to note that each of the nine lesions reported as well was in a patient who had an arrested bone or joint lesion of many years' duration, and it is, of course, the bone and joint lesions which are here recorded as being well. By "well" is meant that in bone the lesion has been arrested; in joint there is ankylosis, either with impairment or loss of motion and function. Of the other patients in this group, several are under treatment and others were still under observation for their pulmonary disease when last seen.

Analysis of Deaths

Death in Relation to Age: Chart II shows the mortality in relation to age, and clearly demonstrates the gravity of tuberculous joint disease in the second and third decades and in the aged. These are also the age periods in which pulmonary and other tuberculous diseases are most frequently fatal. Thus either of these manifestations of the disease is

TABLE IV

End Result of Bone and Joint Lesions in Relation to Lung Disease in 160 Patients

Condition of Local Lesion	Total		Non-Pulmonary (*42 Patients*)		Pulmonary (*118 Patients*)					
					Minimal (*33 Patients*)		Moderately Advanced (*25 Patients*)		Far Advanced (*60 Patients*)	
	Lesions	Per Cent	Lesions	Per Cent.	Lesions	Per Cent.	Lesions	Per Cent.	Lesions	Per Cent.
Well	35	17.2	9	17.0	15	33.3	2	7.2	9	11.7
Improved ..	42	20.7	16	30.2	12	26.7	7	25.0	7	9.1
Unimproved.	26	12.8	4	7.5	8	17.8	6	21.4	8	10.4
Lesions in Survivors...	*103*	*50.7*	*29*	*54.7*	*35*	*77.8*	*15*	*53.6*	*24*	*31.2*
Lesions in non-survivors	100	49.3	24	45.3	10	22.2	13	46.4	53	68.8
Totals....	203	100.0	53	100.0	45	100.0	28	100.0	77	100.0

TABLE V

NUMBER AND LOCATION OF LESIONS IN NON-SURVIVING PATIENTS

Location	Total (*160 Patients*)			Non-Pulmonary (*42 Patients*)			Minimal (*33 Patients*)			Moderately Advanced (*25 Patients*)			Far Advanced (*60 Patients*)		
	Total Lesions	Lesions in 77 Non-Surviving Patients		Total Lesions	Lesions in 16 Non-Surviving Patients		Total Lesions	Lesions in 10 Non-Surviving Patients		Total Lesions	Lesions in 11 Non-Surviving Patients		Total Lesions	Lesions in 40 Non-Surviving Patients	
		No.	Per Cent.		No.	Per Cent.		No.	Per Cent.		No.	Per Cent.		No.	Per Cent.
Spine	67	38	57	22	12	55	15	6	40	7	3	43	23	17	74
Hip	30	13	43	9	5	56	6	1	17	4	1	25	11	6	55
Fingers, toes, and long bones	22	10	45	3	0	0	6	1	17	4	4	100	9	5	55
Knee	17	7	41	1	0	0	6	0	0	3	2	67	7	5	71
Sacro-iliac	15	9	60	5	3	60	4	1	25	1	0	0	5	5	100
Sternum	8	5	63	3	2	67	0	0	0	1	0	0	4	3	75
Elbow	8	4	50	4	1	25	1	0	0	0	0	0	3	3	100
Ribs	7	3	43	1	0	0	1	0	0	2	0	0	3	3	100
Shoulder	7	6	85	0	0	0	1	1	100	2	2	100	4	3	75
Ankle	6	0	0	1	0	0	2	0	0	1	0	0	2	0	0
Wrist	4	1	25	0	0	0	1	0	0	1	0	0	2	1	50
Tarsus	4	2	50	1	0	0	1	0	0	1	1	100	1	1	100
Irregular bones	5	2	40	3	1	33	1	0	0	0	0	0	1	1	100
Tendon, bursae	3	0	0	0	0	0	0	0	0	1	0	0	2	0	0
Totals	203	100	49	53	24	45	45	10	22	28	13	46	77	53	69

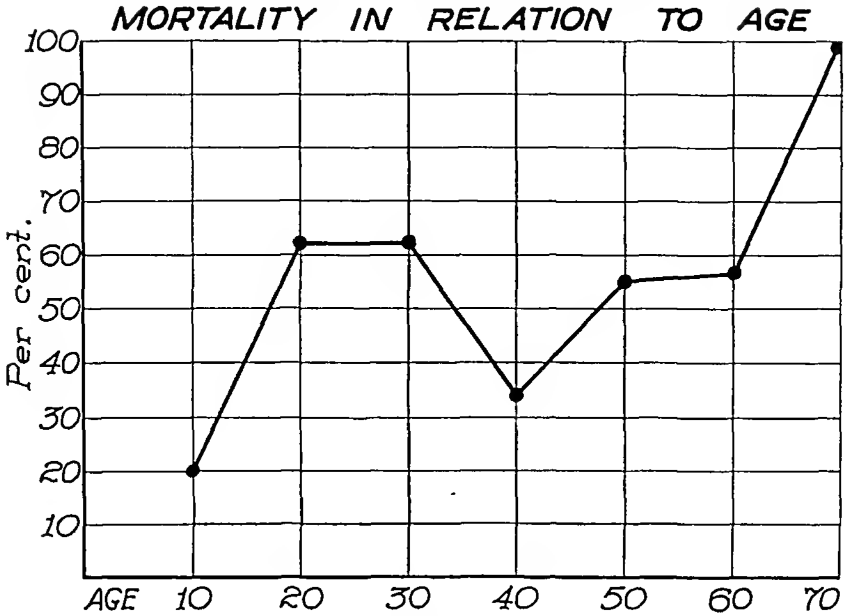

CHART II

The mortality in relation to age is based upon 203 lesions, rather than 160 patients, because of the multiple lesions counted.

often the cause of death, rather than the bone or joint lesion. This, however, does not detract in any way from the serious importance of bone and joint disease which may be present at these ages.

Death in Relation to Race: The susceptibility of the yellow, mixed, and black races to tuberculosis is well known. There were in our series forty-nine lesions occurring in one of the above races, with a mortality of 70 per cent. (based on the number of lesions). In the 154 lesions of the white race, the mortality was by contrast only 43 per cent.

Death in Relation to Pulmonary Involvement: (See Table V.)

(a) Non-pulmonary group: Sixteen patients, with twenty-four, or 45 per cent. of the fifty-three bone and joint lesions, died. This is not unexpected, particularly as they all had multiple lesions. There were twelve instances of tuberculosis of the spine, all of the patients having large abscesses, three of which ruptured internally and six others externally. There was also a high incidence of draining sinuses among the additional four instances of tuberculosis of the hip; three of the sacro-iliac; two of the sternum; and one each, of the sacrum and elbow. Additional complications, one or more of which were present in each case, consisted of paraplegia, meningitis, miliary tuberculosis, multiple bone and joint infection, genito-urinary and glandular foci, skin ulcers, and decubiti. In three instances death could be directly attributed to postoperative shock.

(b) Pulmonary group: Half of the patients with joint involvement plus pulmonary disease died. The stage of the lung disease had a very definite bearing on the outcome as shown in Table V, which dis-

closes that 22 per cent. of the minimal, 46 per cent. of the moderately advanced, and 69 per cent. of the advanced group died. This rapidly rising mortality rate corresponds to the experiences with lung diseases alone or with complications other than orthopaedic ones, and serves to emphasize the need for giving primary consideration to the patient rather than to his local disease.

Death in Relation to Multiple Lesions: The seriousness of multiple lesions is evident. In the 160 patients, there were thirty-four who had multiple bone and joint involvement, making in all 77 lesions. Of these thirty-four patients, seventeen, or 50 per cent., died, and the lesions in eight, or 23.5 per cent., were unimproved; in four, or 11.8 per cent., improved; and in five, or 14.7 per cent., well.

Death in Relation to a Positive Sputum Examination: There has not been enough emphasis placed upon the existence of a positive sputum examination in patients who have orthopaedic lesions. The authors believe that the presence of tubercle bacilli in the sputum is a contra-indication to surgical treatment. Of fifty-seven patients, with sixty-eight lesions and positive sputum, thirty-seven died; and the lesions in eight were unimproved; in eight, improved; and in only four, well. In other words, 79 per cent. of the patients with positive sputum either died or failed to improve.

Death in Relation to Existence of a Sinus: It has long been recognized that a draining sinus greatly increases the hazards of tuberculous disease. In this series, ninety-two patients had this complication, of whom fifty, or fifty-four per cent. died. Of the forty-two survivors, thirteen patients had lesions which were unimproved, seventeen improved, and twelve were well; sepsis and amyloid disease were the cause of death in many instances.

Death in Relation to Treatment: A discussion of methods of treatment is not being presented in this paper, but the cases have been segregated into two divisions. The first consists of 118 lesions treated by rest and immobilization; sixty-three, or 53 per cent., were in patients who died; seventeen, or 14 per cent., were unimproved; nineteen, or 16 per cent., improved; and nineteen, or 16 per cent., well. Admittedly many of these lesions were in the advanced pulmonary group, and many had complications.

In the second division there were eighty-five lesions treated surgically. Many of the operations were merely sinus excision or abscess incision, although amputations and arthrodeses are also included. Of these thirty-three were in the non-pulmonary group, and fifty-two in the groups with pulmonary involvement. The end results were: thirty-eight, or 44 per cent., in patients who died; eight, or 9 per cent., unimproved; twenty-three, or 27 per cent., improved; and sixteen, or 19 per cent., well.

The results of treatment are difficult to evaluate when they are based on patients. In a few of the patients with multiple lesions, one joint may have been treated by rest or immobilization only, and the associated lesion by some form of surgery. Then there was a variance

in the final result in six of the patients in whom one joint was unimproved, and the other well or improved. In the count, three were considered favorable and three unfavorable in result. The mortality then, in relation to treatment, was as follows: Of eighty-eight patients treated by rest or immobilization only, forty-nine died; and the lesions in ten were unimproved; in fifteen, improved; and in fourteen, well. Of seventy-two patients treated surgically, twenty-nine died; and the lesions in six were unimproved; in twenty-one, improved; and in sixteen, well.

SUMMARY AND CONCLUSIONS

The analysis of the bone and joint tuberculosis encountered in a general tuberculosis hospital during the fifteen years from 1920 to 1935 shows that:

1. Of 4252 tuberculous patients, 160 or 3.76 per cent. had 203 single or multiple tuberculous joint and bone lesions, which were usually secondary to some other tuberculous focus, most frequently in the lungs.

2. Of these 160 patients, 118, or 73.7 per cent., had chronic pulmonary tuberculosis; forty-two, or 26.3 per cent., had no pulmonary involvement but had fifty-three bone and joint lesions, or 26 per cent., of the total orthopaedic lesions. Of these patients with fifty-three lesions, forty-five had manifestations of tuberculosis elsewhere,—in bones and joints, or skin, or as adenitis, polyorrhomenitis, etc. In only eight was one joint the sole focus of tuberculosis.

3. Bone and joint tuberculous disease affects more often the weight-bearing joints in the order indicated in Table II.

4. It is most prevalent in the second and third decades of life.

5. When tuberculous bone and joint lesions are associated with pulmonary disease, the outcome is greatly influenced by the degree of lung involvement and is particularly serious in the moderately advanced and far-advanced stages. Complications were present in the greatest number in the patients with far-advanced pulmonary tuberculosis. The orthopaedic lesions, therefore, should be secondary in importance to the care of the pulmonary disease. Surgery for patients in these advanced stages of the disease must be carefully considered; conservative measures alone are the methods of choice.

6. The prognosis is more serious in patients who have tubercle bacilli in the sputum; in patients in whom there is a draining sinus or multiple abscesses (very often a general toxaemia ensues in the former, and the development of amyloid disease in the latter); and in those with forms of tuberculosis other than pulmonary.

7. The end results show that in 160 patients with 203 bone and joint lesions, thirty-five or 17 per cent. of the lesions were well; forty-two, or 21 per cent., were improved; twenty-six, or 13 per cent., were unimproved; and 100, or 49.3 per cent., were in patients who have died.

8. In a study of bone and joint tuberculosis in a general tuberculosis hospital where far-advanced pulmonary cases constitute a large

proportion of the patients, the mortality statistics are necessarily higher than in a service with orthopaedic patients alone. In this series the mortality was highest in the second, third, and seventh decades. It was greater in the pulmonary cases (51 per cent. of the patients with 50 per cent. of the lesions) than in the non-pulmonary cases (38 per cent. of the patients with 45 per cent. of the lesions); and greatest in those with multiple joint lesions. It was also higher in the yellow, mixed, and negro races. This indicates an unusual susceptibility and lowered resistance, and for this reason very careful consideration must be given each patient before surgical procedure is undertaken. Of the patients with positive sputum 79 per cent. died or had lesions which failed to improve; and of ninety-two patients with one or more sinuses, sixty-three died or had lesions which failed to improve.

9. An analysis of the 118 bone and joint lesions treated by rest and immobilization shows that sixty-three, or 53 per cent., were in patients who died; seventeen, or 14 per cent., were unimproved; nineteen, or 16 per cent., were improved; and nineteen, or 16 per cent., were well. Of the eighty-five joints treated by surgery of any kind, thirty-eight, or 44 per cent., were in patients who died; eight, or 9 per cent., were unimproved; twenty-three, or 27 per cent., were improved; and sixteen, or 19 per cent., were well.

10. Because this study has brought out so conclusively the high mortality in bone and joint tuberculosis when associated with pulmonary involvement, the authors wish to emphasize the necessity of a complete physical examination including routine laboratory work and roentgenograms of the chest for every patient.

[1] Cleveland, Mather: Surgical Treatment of Joint Tuberculosis. Surg. Gynec. Obstet., LXI, 503, 1935.

A SIMPLE METHOD OF TWO-STAGE TRANSPLANTATION OF THE FIBULA FOR USE IN CASES OF COMPLICATED AND CONGENITAL PSEUDARTHROSIS OF THE TIBIA *

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The purpose of this communication is to describe a simple method of two-stage transplantation of the fibula into the tibia, and to report the results obtained by its use in a group of nine cases of complicated pseudarthrosis of the tibia.

HISTORICAL

Transplantation of the fibula to replace defects in the tibia was first conceived by Hahn in 1884, but he transferred only the upper end into the proximal fragment. Subsequently Codivilla pointed out the advisability of also transferring the lower end into the distal fragment of the tibia in order to overcome the valgus deformity of the foot. Huntington perfected the technique of this operation in 1905, and reported a case in which he had successfully bridged a gap of five inches in the tibia. He described a two-stage procedure in which he first exposed the shaft of the fibula on a level with the lower end of the upper fragment of the tibia. He divided the fibula and transplanted the upper end of the distal fragment into a cup-shaped depression in the tibia. After fixation in a plaster casing for eight to ten weeks, he performed the second stage of the operation. The lower portion of the fibula was exposed on a level with the upper end of the distal tibial fragment and transplanted into a cup-shaped depression.

Stone, in 1907, reported a modification of the Huntington technique, in which he split the distal portion of the fibula shaft into two halves and then divided one half at the external malleolus. He transferred this fragment into the distal end of the tibia, and was thus able to elongate a short leg. Campbell, in 1919, reported three cases of tibial pseudarthrosis in which he excised the cartilage and ligaments from the upper tibiofibular articulation, and buried the head in the tibial tuberosity. He performed this operation as a preliminary to later bone-grafting operations on the tibia, and did not consider it necessary to transfer the lower end. He pointed out the stabilizing effect of this operation upon the pseudarthrosis, and considered that it increased the chances of a successful result from the bone graft.

The literature abounds with reports of cases, either single or in small groups, where transference of the fibula was done with successful results. In general, the method was employed only when there existed large defects in the tibia, and varying operative techniques were used, often involving

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complete separation of the transplanted portion of the fibula from its blood supply. In particular, the method proved useful in defects resulting from diaphyseal resections of the tibia for acute osteomyelitis.

INDICATIONS

It is the author's belief that transference of the fibula into the tibia has a much wider application than this; and that it ought to be considered in all cases of complicated or infected pseudarthrosis, even where there is no gross loss of tibial substance, particularly when bone-grafting operations have previously failed, or seem for the moment to hold very little promise of success. In the author's hands the method also proved particularly valuable in cases of congenital pseudarthrosis or of congenital bowing in which pseudarthrosis subsequently developed.

The operation here described was first employed by the author in 1926. The technique was later improved and simplified, and the method has now been employed in a total of nine cases which are herewith reported. In one early case (Case 2), it was necessary to operate three times before union of the upper end of the fibula to the tibia was obtained. In one other case (Case 9), union of the upper end was doubtful, but, since healing of the pseudarthrosis took place promptly afterward, it would seem to be fair to consider the result successful. In the other cases osteosynthesis of the fibula to the tibia resulted uneventfully.

OPERATIVE PROCEDURE

The operation is best done in two stages although in one case both ends were transplanted at the same time. The two-stage method has the advantages of lessening the risk of dislodging the end of the fibula from its connection with the tibia, of shortening the time of the operation, and of reducing the severity of the postoperative reaction.

First Stage of Operation (*Upper End*)

The operation should be performed with a tourniquet about the thigh. An oblique incision is made over the lateral aspect of the knee and upper leg, beginning at a point three inches above the head of the fibula at the posterior border of the biceps femoris tendon, and extending downward and forward to the tibial crest at a point two to three inches below the tibial tubercle. The skin and superficial fascia are dissected back on either side of the incision to expose the deep fascia, the head of the fibula, the lateral surface of the external tuberosity of the tibia, and the tibial crest (Figs. 1, 2-A, 2-B, and 2-C). The common peroneal nerve is identified behind the biceps tendon, picked up in a tape, and carefully dissected free as it passes around the neck of the fibula and divides into its deep and superficial branches. A transverse incision is now made along the inferior border of the lateral tuberosity of the tibia at the point of attachment of the tibialis anterior muscle, and extended anteriorly and downward, following this border as it curves distally, to meet the tibial crest. This incision

extends posteriorly until it meets the incision over the neck of the fibula which has exposed the common peroneal nerve (Fig. 2-A). With a periosteal elevator the muscle flap, which has thus been outlined, is stripped away from its attachment to the upper end of the fibula and the lateral tuberosity of the tibia, and retracted downward. By retracting the nerve with the tape and stripping the muscles away from the fibula, an excellent exposure is obtained of the upper part of the fibula, of the shelving under surface of the lateral tuberosity of the tibia, and of the interosseous membrane. The anterior tibial artery and vein may be seen emerging from the popliteal space through the opening at the upper edge of the interosseous membrane, and coursing downward on the anterior surface of the latter. These vessels interfere with the transference of the fibula, and must usually be ligated and cut.

The fibula is now divided at the neck with a sharp osteotome (Fig. 2-B), and the upper end of the distal fragment is seized with a bone clamp and pulled medially toward the tibia, in order to determine both the proper point for its lodgement in the tibia, and also the amount of force necessary to approximate it to the tibia. Forcible outward displacement of the foot and leg below the pseudarthrosis facilitates this task. In some cases, usually determined beforehand from a study of the roentgenograms, there may be interference with the medial displacement of the upper end of the fibula from the impingement of a mass of callus at the lateral surface of the pseudarthrosis, or from the lateral bowing or displacement of the fragments of the tibia. When approximation of the upper end of the fibula to the tibia cannot be obtained without the use of undue force, it is necessary to perform a partial osteotomy of the fibular shaft lower down, and produce a greenstick fracture which will allow it to be bent inward until contact with the tibia is obtained.

The fusion of the fibular shaft to the tibia is made by lifting up a flap of cortical bone on the lateral surface of the upper end of the tibia, and excavating a bed underneath of sufficient size to lodge the end of the fibula (Fig. 2-C). Bone chips may be packed in

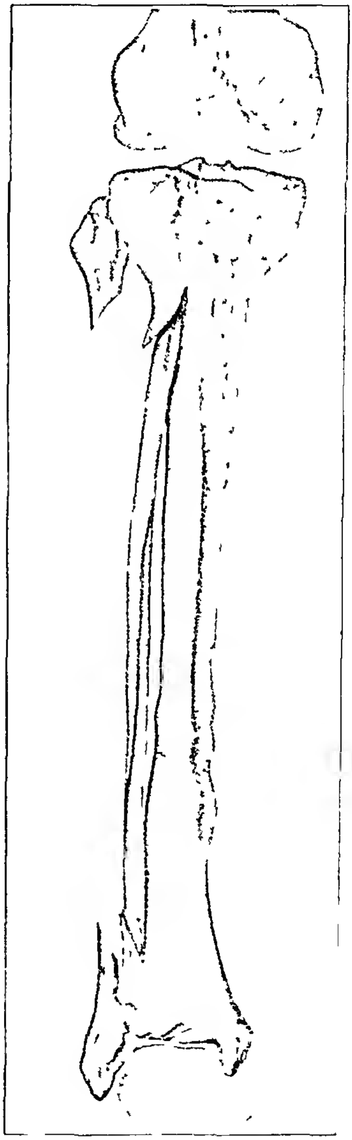

FIG. 1

Diagrammatic representation of completed operation.

and about the point of junction to make union more certain. Whether or not some form of metallic fixation should be employed depends upon how much tendency there is for the fibula to spring away from the tibia. In the case of an adult, because of the rigidity of the fibula, this is a wise precaution. The simplest method of fixation is a screw passed through the fibula into the tibia until its threads engage the opposite cortex.

Following fixation of the fibula to the tibia, the wound is closed. The muscle flap is replaced in its original position and its edges are sutured to the adjacent fascia. The common peroneal nerve is allowed to drop back into its original bed and the fascia is closed. The skin edges are sutured, following which the leg is carefully supported and a plaster casing applied, extending from the toes to the upper thigh.

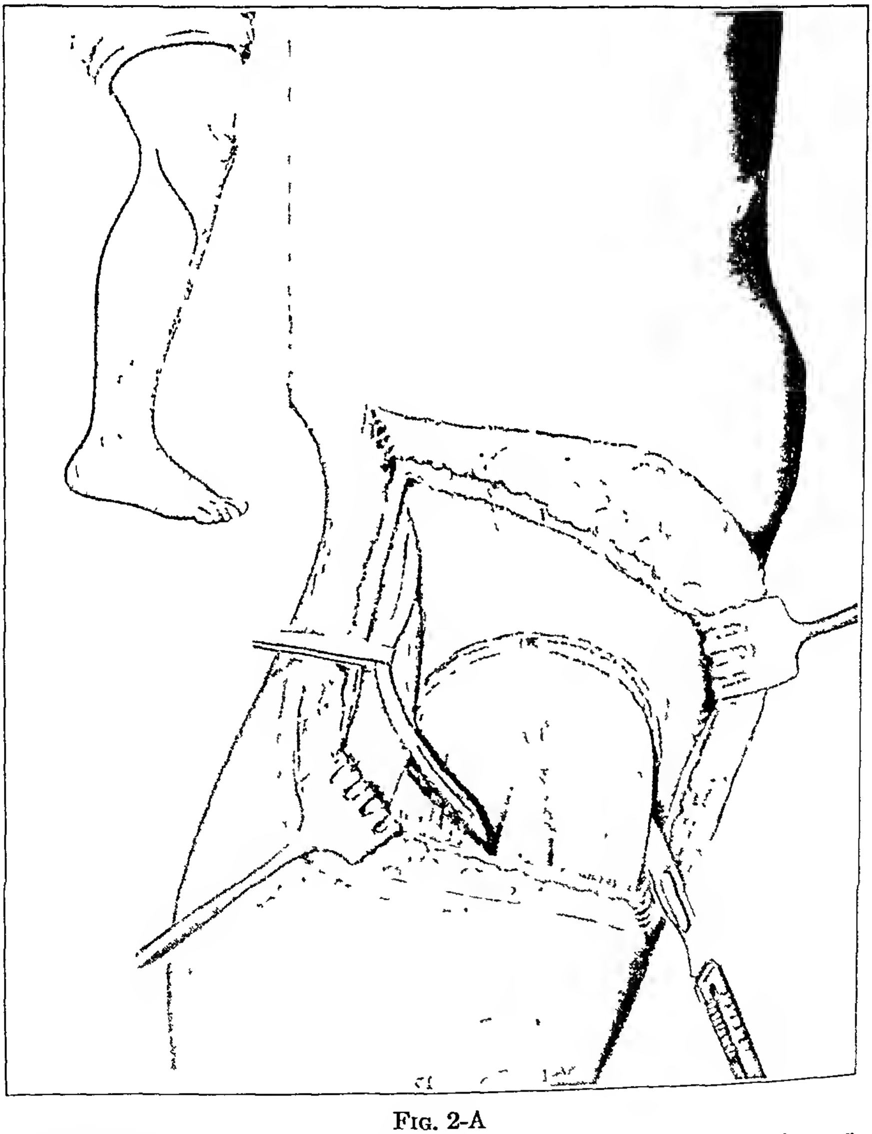

FIG. 2-A

Transplantation of upper end of fibula. Incision and separation of upper muscle flap.

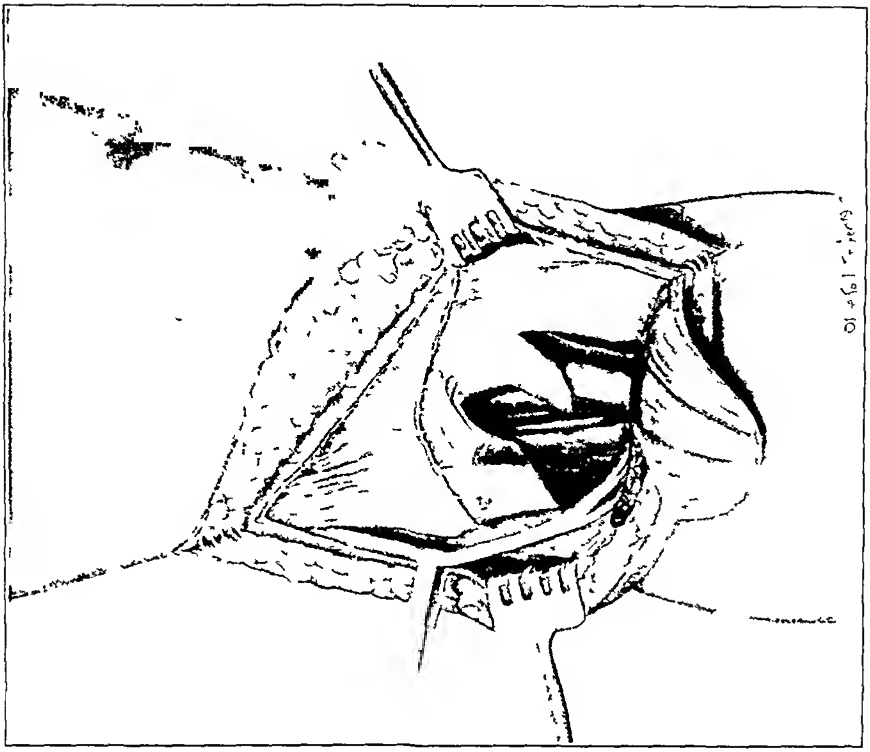

FIG 2-C
Transplantation completed.

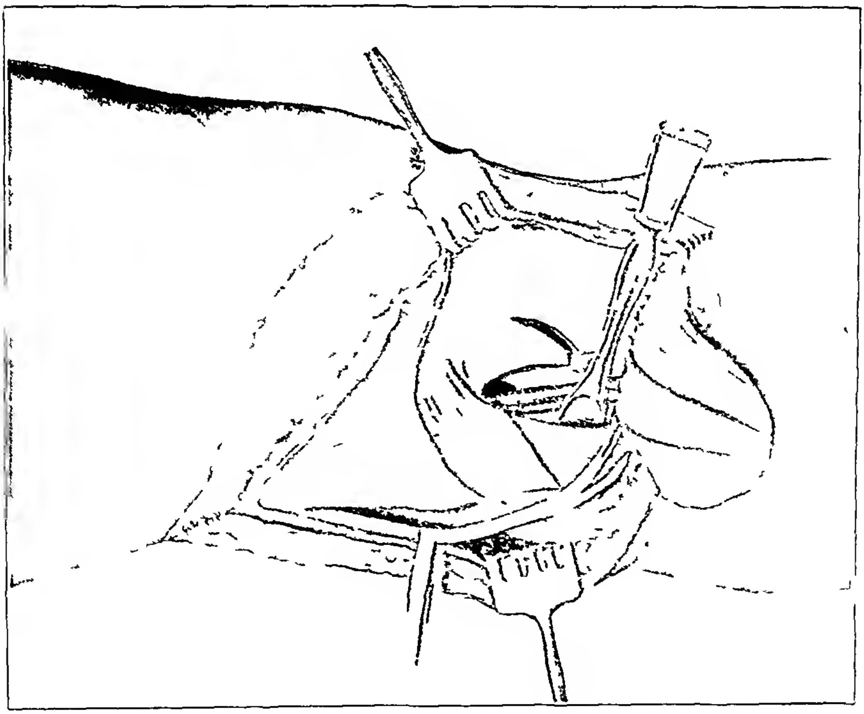

FIG 2-B
Exposure completed preparatory to transplant

Second Stage of Operation (Lower End)

The second stage of the operation should usually be delayed for about four weeks, or until the union of the upper end of the fibula with the tibia is secure. The aim is to produce a synthesis of the lower portion of the fibular shaft with the tibia, just above its point of junction with the latter. This operation is simple and requires no long description. With a tourniquet about the thigh, an incision about five inches long is made in the long axis of the limb over the anterior surface of the lower third of the leg at a point about midway between the tibia and fibula. The fascia is opened, freed from the underlying muscles, and retracted widely enough on either side to expose the fibula and tibia (Fig. 3-A). The shaft of the fibula is exposed subperiosteally, and divided with an osteotome in an oblique plane from below upward and outward, beginning just above the tibiofibular junction. The lateral surface of the lower portion of the tibia is exposed and, working outward with a blunt instrument from this point and inward from the region of the fibula, an opening is made between the interosseous membrane and the muscles lying anterior to it. The lower end of the fibular shaft is pulled through this opening and approximated to the lateral surface of the tibia. A flap of cortex is then split away from the lower end of the tibial shaft and a hole excavated behind it at the proper level, in which the lower end of the fibula can be securely lodged (Fig. 3-B). The incision is closed in layers, and a plaster casing is applied, extending from the toes to the upper thigh.

It is considerably easier to form the junction between the lower end of the fibula and the tibia than at the upper end, and it has been necessary to employ metallic fixation in only one instance. It should be pointed out, however, that in four out of five of the cases of congenital pseudarthrosis there was a pseudarthrosis of the fibula as well as of the tibia, and in these the second stage of the operation was atypical. The pointed lower end of the upper fragment was inserted in a hole in the upper end of the distal tibial fragment. Because of the shortness of the fibular fragment, some difficulty was encountered in approximating the bones. In one case (Case 6), the fibula pulled out of the tibia and approximation of the bones was lost. In this case a second operation was performed and osteosynthesis completed by the use of sliver grafts, layed in contact with the fibula and tibia, and held in place by the closure of the periosteum and muscles.

AFTER TREATMENT

Complete immobilization in plaster was employed in these cases for varying periods of months. Union of the fibula to the tibia usually was solid in from six to eight weeks after the operation. Generally at the end of about three months, a walking stirrup of steel was incorporated in the plaster, and weight-bearing on the affected limb was encouraged. As long as there was a chance of union of the tibial pseudarthrosis, complete immobilization in plaster was continued, in some instances up to one year.

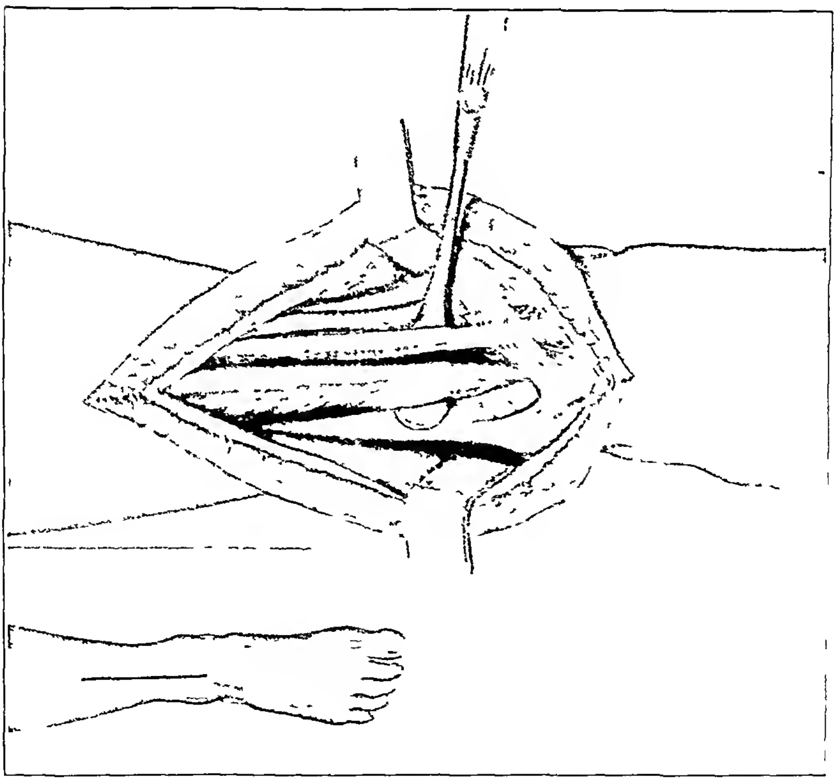

Fig. 3-A

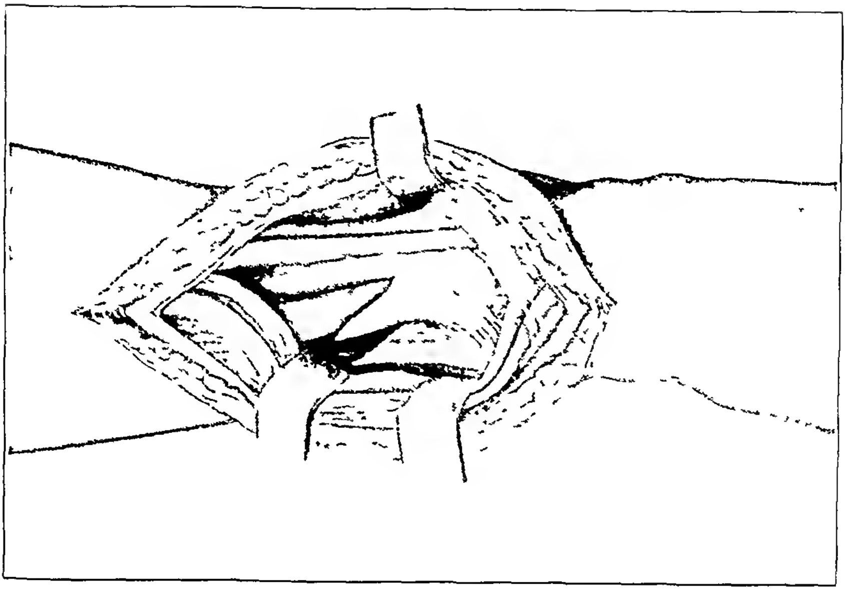

Fig. 3-B

Transplantation of lower end of fibula.

Fig. 3-A: Exposure preliminary to transplantation.

Fig. 3-B Transplantation completed.

When there was loss of substance of the tibia and union at this point could not be expected, a double upright brace, with sole plate, knee joint, and a laced leather cuff about the lower leg, was generally employed. Weight-bearing in this was encouraged, and the patients were instructed to get rid of crutches. At a later time a bone-grafting operation was performed and union promptly resulted.

CASE REPORTS

Case 1. A. N. A female, aged thirty-five years, on December 23, 1926, sustained a compound comminuted fracture of the bones of the right leg at the junction of the middle and lower thirds. After débridement and a large loose fragment of bone had been removed, the wound healed by granulation without serious infection, but, because of loss of bony substance, there was failure of union. On October 20, 1927, an attempt was made to obtain union by the use of multiple bone chips and an osteoperiosteal graft, but this resulted in failure. On July 6, 1928, a massive bone graft, eight inches long, was removed from the opposite tibia and inlayed across the line of fracture. At the end of five months this operation appeared to be successful, but later absorption of the graft occurred, and the pseudarthrosis was reestablished at the old level.

It was decided to perform a two-stage side transplantation of the fibula. The first operation was performed at the Massachusetts General Hospital on September 19, 1929. With considerable difficulty and hemorrhage, as the simplified technique previously described had not yet been developed, the upper end of the fibula was transplanted into the upper end of the tibia. It was secured by the insertion of three steel screws and immobilization in plaster. There were no complications, and at the end of forty days the second stage of the operation was done, and the lower end of the fibula was transferred into the tibia. Plaster fixation was continued for three months when a brace was fitted. The roentgenographic examination at this time showed union of both ends of the fibula with the tibia and the beginning of union of the tibial fragments at the point of pseudarthrosis. One year after the last operation there was solid union of the tibia; the woman was walking normally, and had resumed work as a domestic. There was good alignment and excellent function of the knee and ankle.

Case 2. M. D. A female, aged twenty-four years, was admitted to the Massachusetts General Hospital in February 1929, with a history of a fracture, probably compound, of the left tibia in childhood. Infection developed, and there was a draining wound until five years previous to admission, when, after an operation was performed, the wound healed. One year before admission an abscess developed in the scar and ruptured spontaneously with the discharge of a fragment of bone. After several weeks, the wound healed and had remained closed for ten months. The leg had always been deformed and weak, and had required the use of a brace, but for the last four years she had been able to bear full weight on it with perfect comfort.

Examination showed marked shortening and outward bowing of the left leg with a long, broad, thin scar on the anteromedial surface. Definite abnormal mobility could be demonstrated at the middle of the leg. The roentgenographic examination showed an ununited fracture of the tibia with an enormously hypertrophied fibula.

In February it was decided to excise the pseudarthrosis, to attempt to lengthen the leg by a Z-shaped osteotomy, and later to correct the pseudarthrosis by a bone transplant. Kirschner wires were inserted at the upper and lower ends of the tibia, and skeletal traction and countertraction were applied. The lengthening proceeded satisfactorily and about two inches were gained, but the ends of the fragments projected anteriorly and broke through the overlying skin. On April 17, 1929, the pins were removed and a plaster casing applied. The wound on the anterior surface drained and several operations were performed to remove the projecting bone ends and obtain healing. On June 18 the patient was discharged with the leg in plaster.

She was readmitted September 11, 1929, still with an ununited fracture of the tibia and a granulating wound one inch in diameter. Operation was performed September 14, 1929, and a sequestrum removed. It was thought that a two-stage transplant of the fibula into the tibia could be done safely by blocking off the draining wound. The first stage of the operation was performed September 30, 1929, and the upper end of the fibula was transferred to the tibia. Considerable difficulty was encountered in establishing contact of the bones, because of the impingement of the fibula against the bowed tibia at about its middle. The fibula was held against the tibia with two steel screws. The leg was fixed in plaster. Recovery was uncomplicated and the patient was discharged October 12, 1929.

Readmitted January 30, 1930, the patient still had a draining wound over the middle of the tibia. The second stage of the operation was performed, and the lower end of the fibula was transferred into the tibia. She was discharged with the leg in plaster February 18, 1930.

The patient was readmitted October 11, 1930, because the upper end of the fibula had failed to unite with the tibia. On October 14, 1930, the point of the upper transplant was exposed, the metal screws were removed, and bone chips were packed about the synostosis. She was discharged November 4, 1930, with the leg in plaster.

The patient was readmitted October 24, 1933; she had been walking with a brace. The wound over the tibia had healed, but the upper end of the fibula and tibia had still failed to unite. On October 27, 1933, the shaft of the fibula was divided at the junction of the upper and middle thirds; the upper end of the distal fragment was implanted into the upper fragment of the tibia, and fixed with transfixion screws. She was discharged November 14, 1933, with the leg in plaster.

On August 20, 1934, the patient was readmitted. She had worn a plaster casing for four months following the last operation, and then had used a long leg brace. There was solid union of the fibula to the tibia, and the leg was stable. The wound on the anterior surface of the tibia was again discharging. The scar was excised, and a transfer of a pedicle skin flap was done with successful result. The patient was discharged September 28, 1934.

When the patient was last seen, November 17, 1936, there had been no further discharge from the leg wound, bony union was solid, and the patient was walking without brace support. There was good alignment, with shortening of one inch, and excellent function.

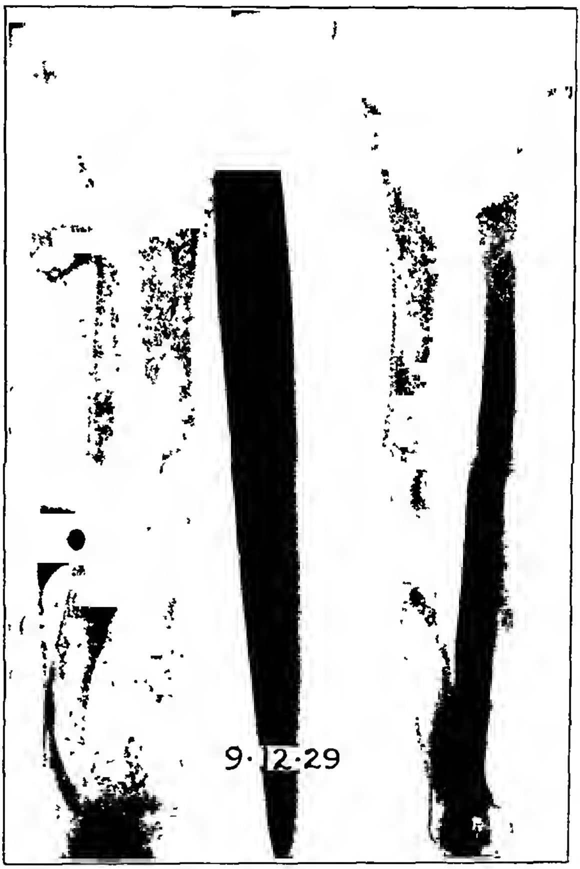

Fig. 4-A
Case 2

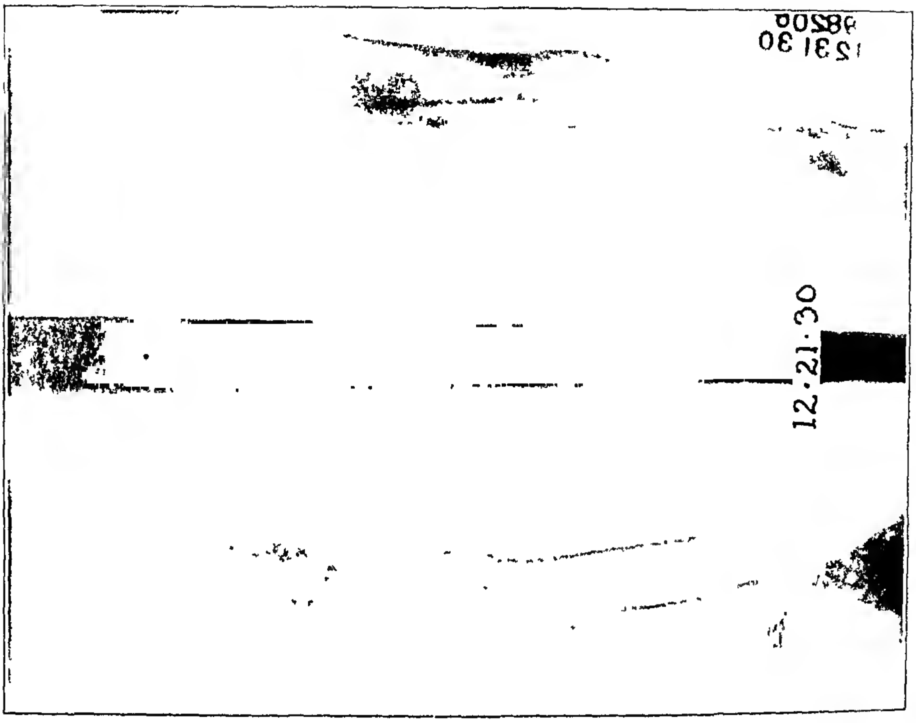

Fig. 4-C
Case 2

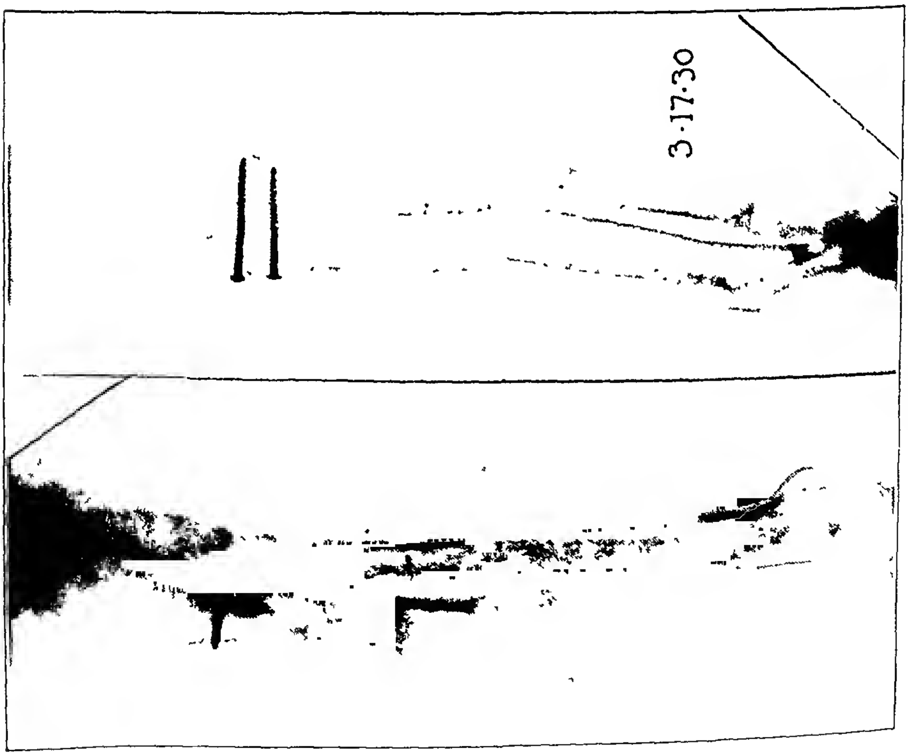

Fig. 4-B
Case 2

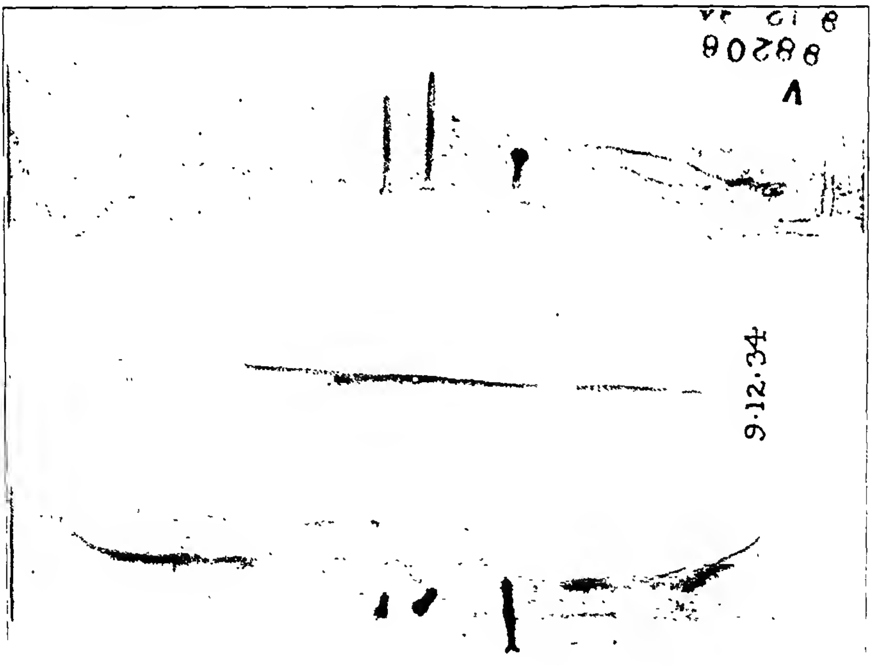

Fig. 4-D
Case 2

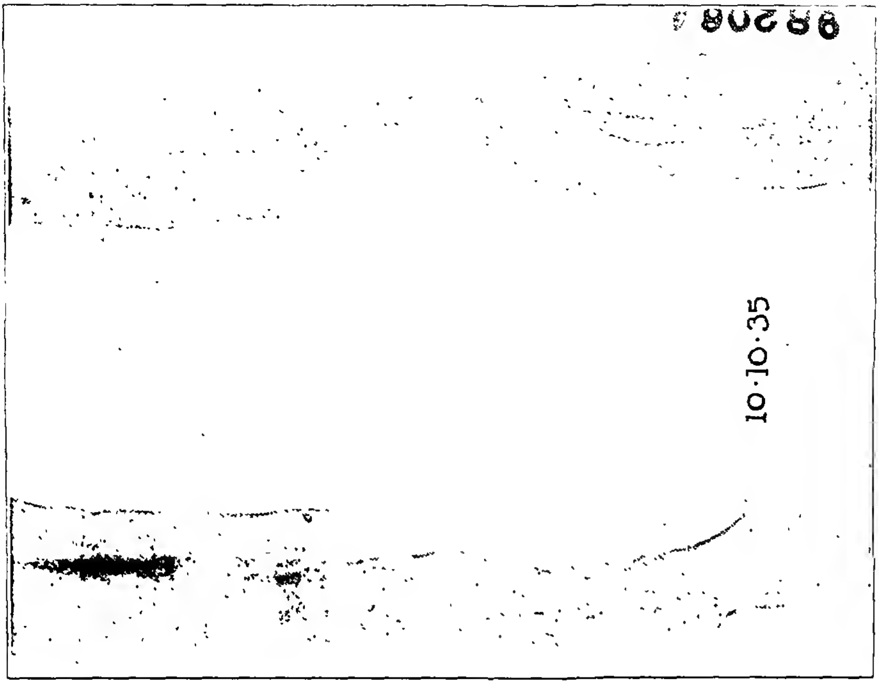

Fig. 4-E
Case 2

CASE 3. D. S. (No. H25-675). A male, aged eight years, was admitted to the Hospital for the Ruptured and Crippled in April 1937, with a diagnosis of congenital bowing of the left leg, pseudarthrosis of the tibia, and neurofibromatosis of von Recklinghausen. He had been followed continuously at the hospital since the age of nine months. At the age of three years an osteotomy of the tibia was performed, which was followed by failure of union. The leg was immobilized in plaster continuously for twenty months, at which time a transplant of a large bone graft from the right tibia into the left tibia by the inlay method was done. In January 1934, four months after the operation, there was union at the site of the old osteotomy, but absorption at the lower end of the bone graft, where a pseudarthrosis was developing. Weight-bearing in a plaster casing was permitted. In April 1935, the fibula was divided, the eburnated ends of the tibia excised, and the leg shortened so that the tibial fragments were approximated. They were fixed by the application of a large onlay graft from the opposite tibia, which was secured by the insertion of four steel screws. At the end of six months, the roentgenographic examination showed union at the old level of pseudarthrosis, but absorption at the upper end of the graft, where pseudarthrosis was developing. In December 1936, there was frank non-union of the tibia, and the steel screws were removed by operation.

Examination in April 1937 showed a normally developed, active boy. The left leg was considerably atrophied, and there was abnormal mobility of the tibia in the lower part of the middle third, but the alignment was good. Inspection of the body showed numerous oval, brown pigmented areas on the skin of the trunk, characteristic of the multiple neurofibromatosis of von Recklinghausen.

A two-stage transplantation of the fibula into the tibia was done according to the technique previously described, with an interval of eight weeks between the two operations. All went well, and the roentgenographic examination in October 1937, six months after the operation, showed not only good union between both ends of the fibula and the tibia, but also the beginning of union of the tibial pseudarthrosis. In February 1938, ten months after the operation, this union seemed quite solid, and the patient was allowed to walk with the aid of a long leg brace.

In April 1938, without permission, he walked without his brace and fell, refracturing both fibula and tibia at the junction of the lower and middle thirds. There was no disalignment of the bones and he was treated by immobilization in plaster. The fibular fracture united rapidly, but union of the tibia was slow. Finally, in January 1939, four slender grafts from the opposite tibia were implanted under the periosteum, following the technique described by Hallock. Weight-bearing in a plaster casing was permitted at the end of two months. In December 1939, there was solid union with dense bony reparative tissue about the old fracture site, and the boy was allowed to bear weight in his brace.

When last seen in July 1940, he was getting about actively; the leg was straight and solid, with good function of the knee and ankle, and shortening of two centimeters.

CASE 4. E. G. (No. H17-287). A female aged four years, was admitted to the Hospital for the Ruptured and Crippled in November 1937, with a diagnosis of congenital pseudarthrosis of both bones of the right leg and multiple neurofibromatosis of von Recklinghausen. The child was first seen by the author in November 1934, at the age of eighteen months, because of marked bowing of the bones of the right leg. Roentgenographic examination showed a pseudarthrosis of the tibia at the junction of the middle and lower thirds, and a pseudarthrosis of the fibula at a level one centimeter lower. There was anterior and lateral bowing, and a suggestion of cystic change in the lower end of the upper tibial fragment. The bowing was corrected under anaesthesia, and a plaster casing was applied. In March 1935, there was abnormal mobility at the seat of the fracture. An operation was performed, exposing the ends of the fragments, and multiple drill holes were made in them with a fine drill. The ends of the fibular fragments were approximated and tied together with silk. The leg was immobilized in plaster constantly until the present admission, and weight-bearing was encouraged.

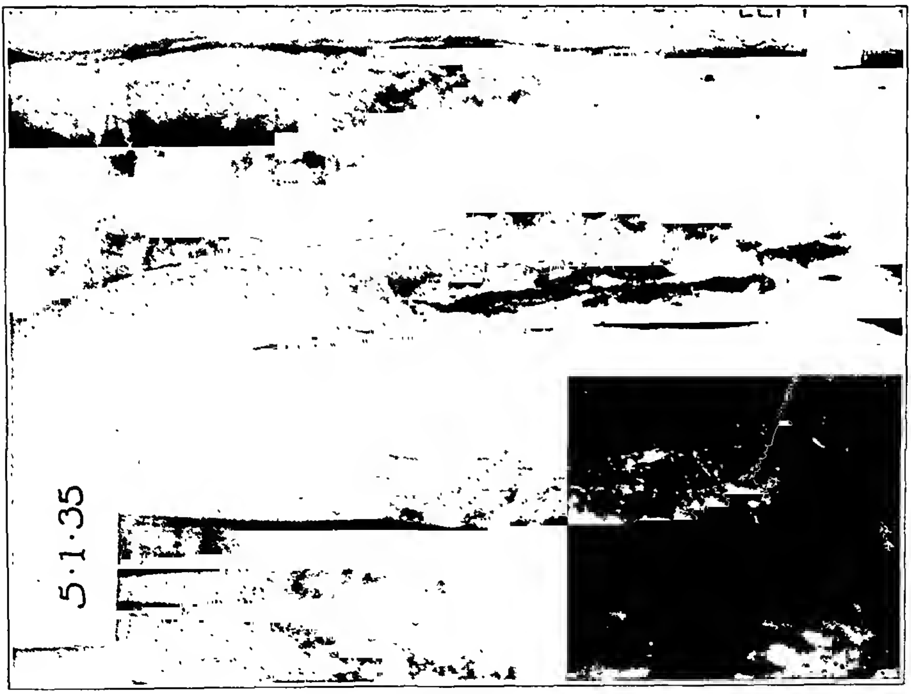

FIG. 5-A
Case 3

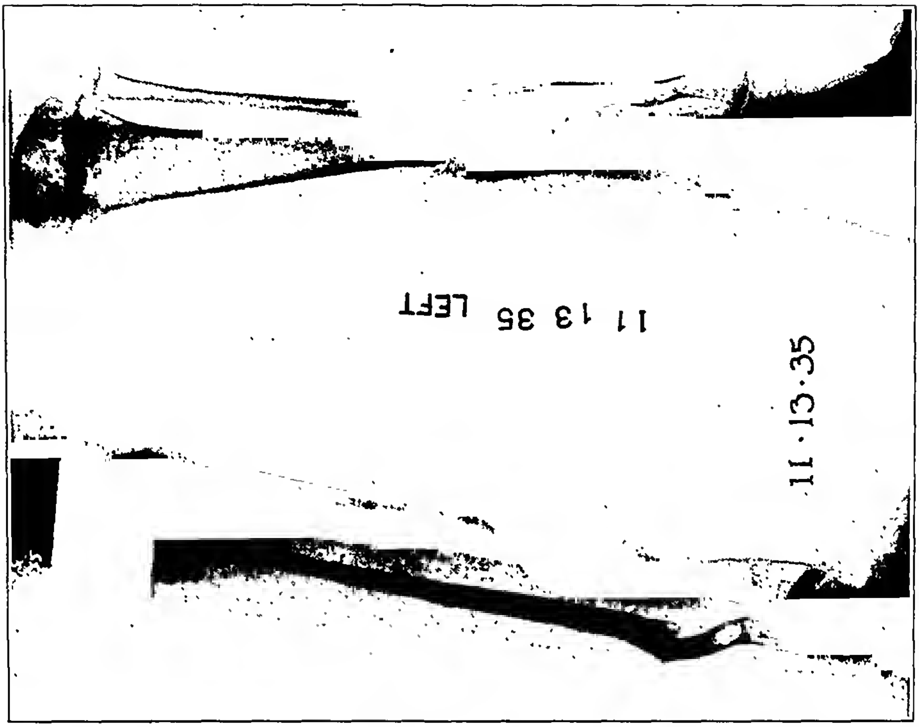

FIG. 5-B
Case 3

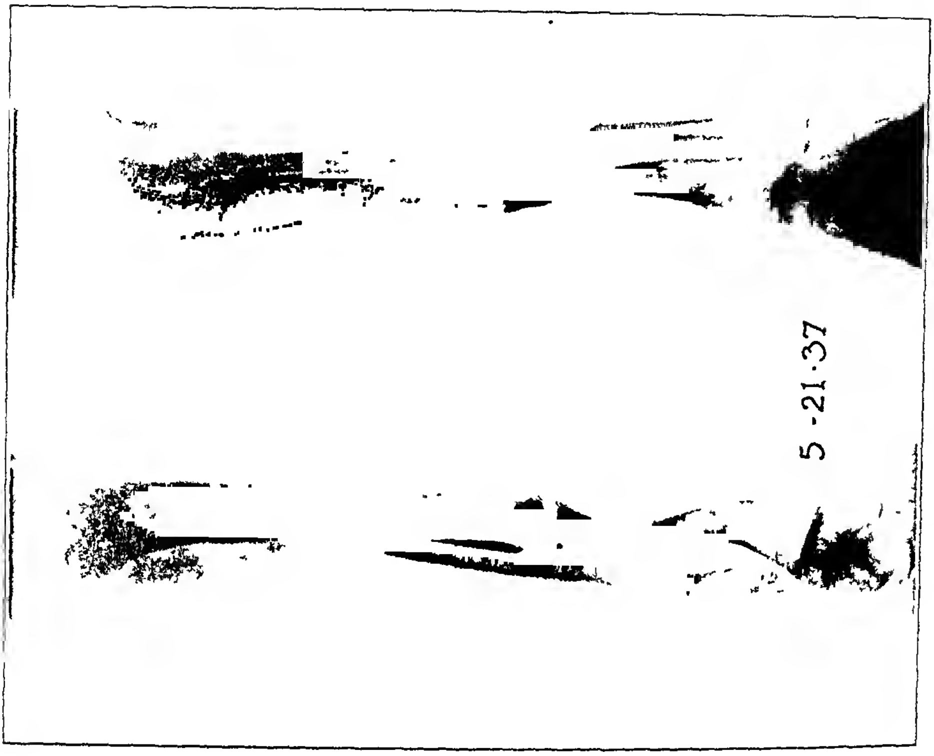

Fig. 5-D
Case 3

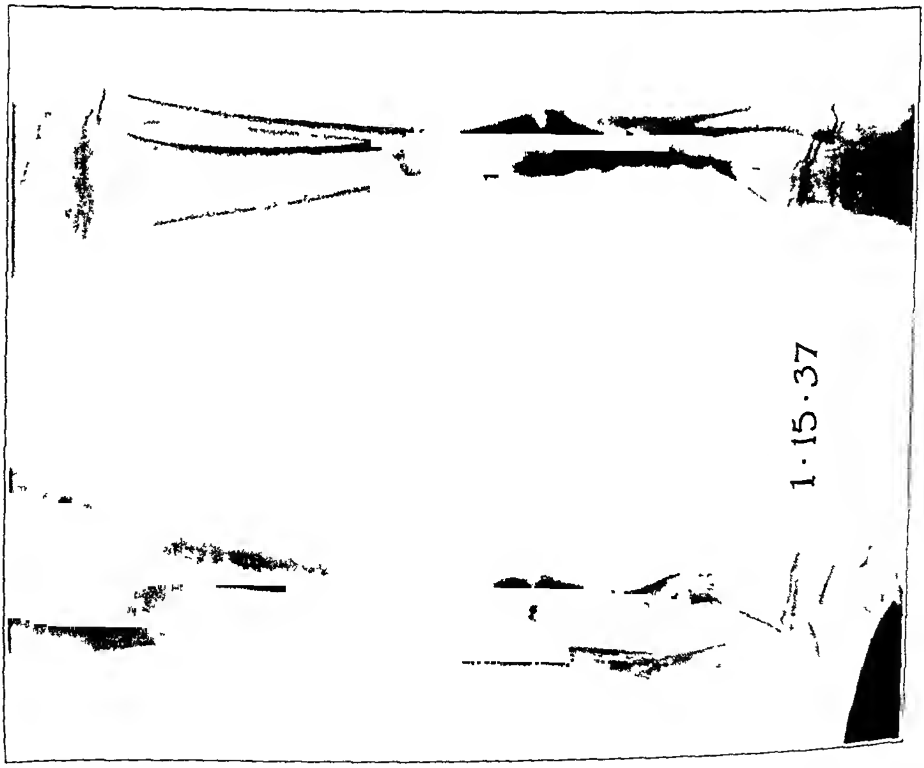

Fig. 5-C
Case 3

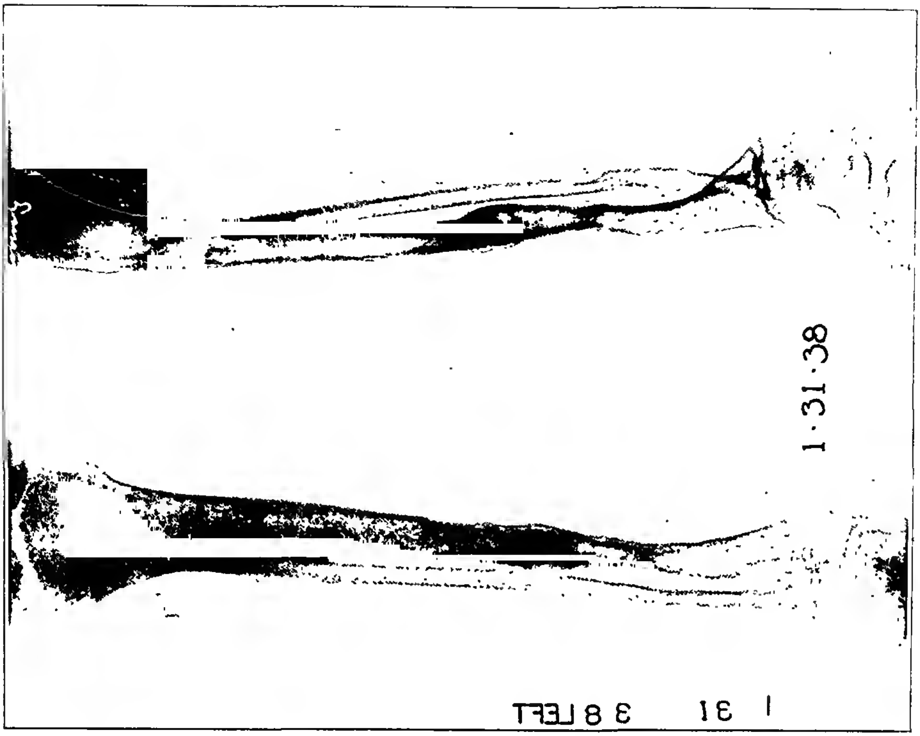

Fig. 5-F
Case 3

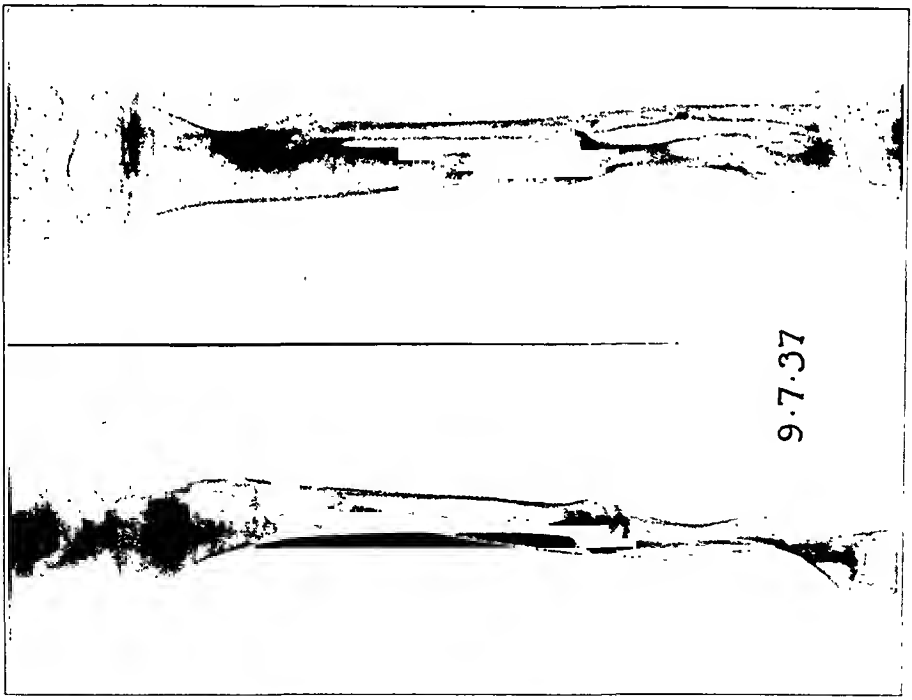

Fig. 5-E
Case 3

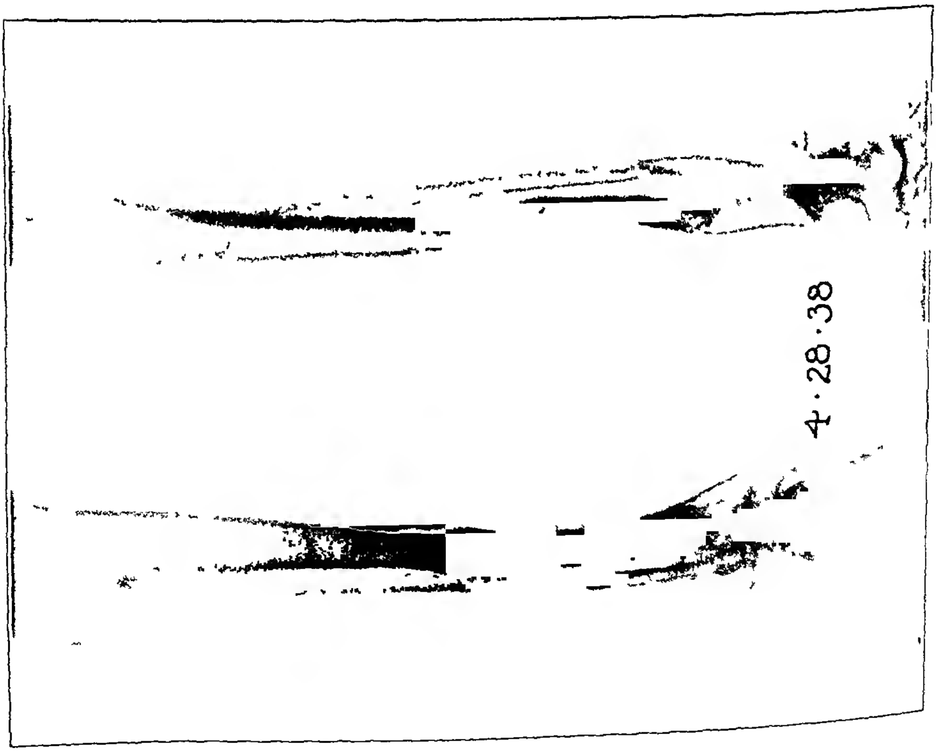

Fig. 5-G
Case 3

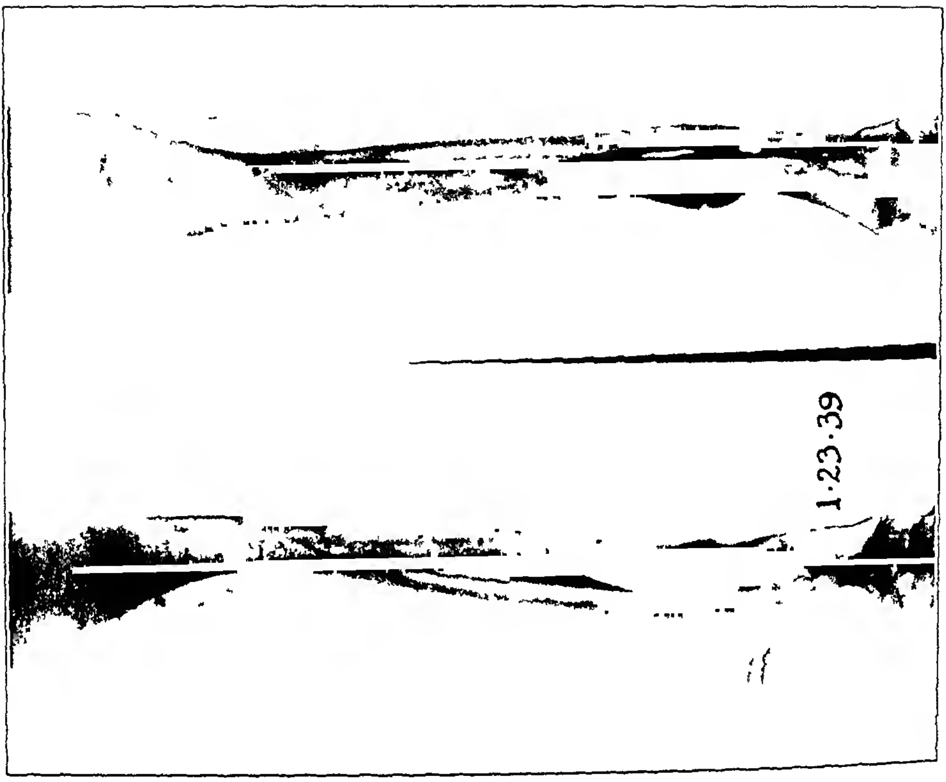

Fig. 5-H
Case 3

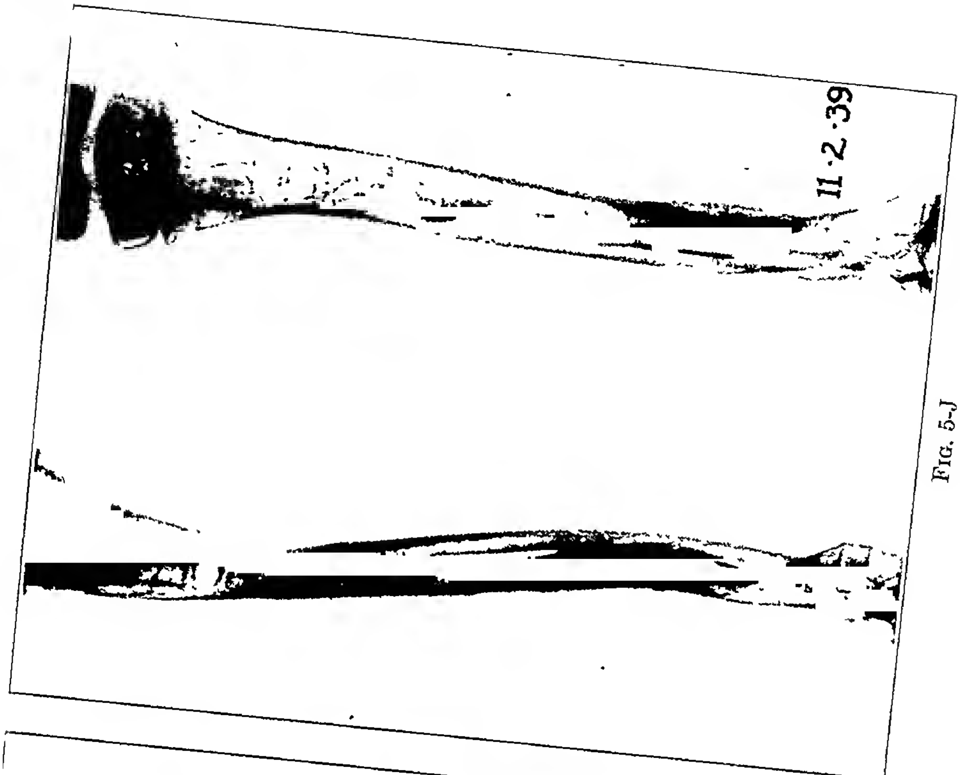

FIG. 5-J
Case 3

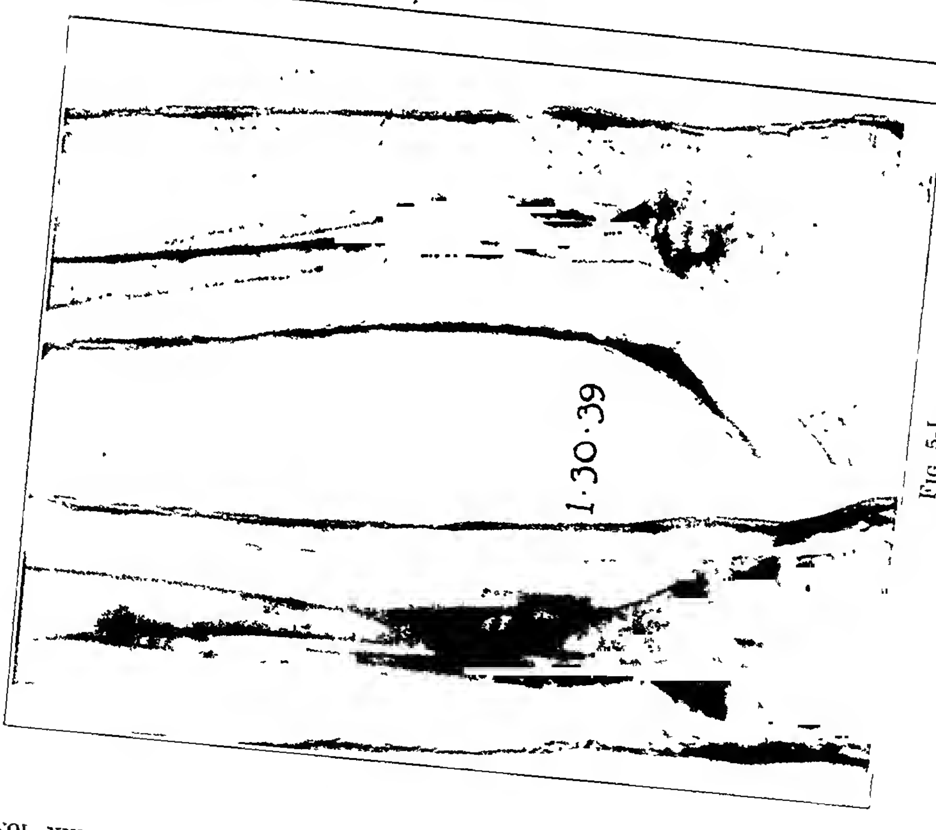

FIG. 5-I
Case 3

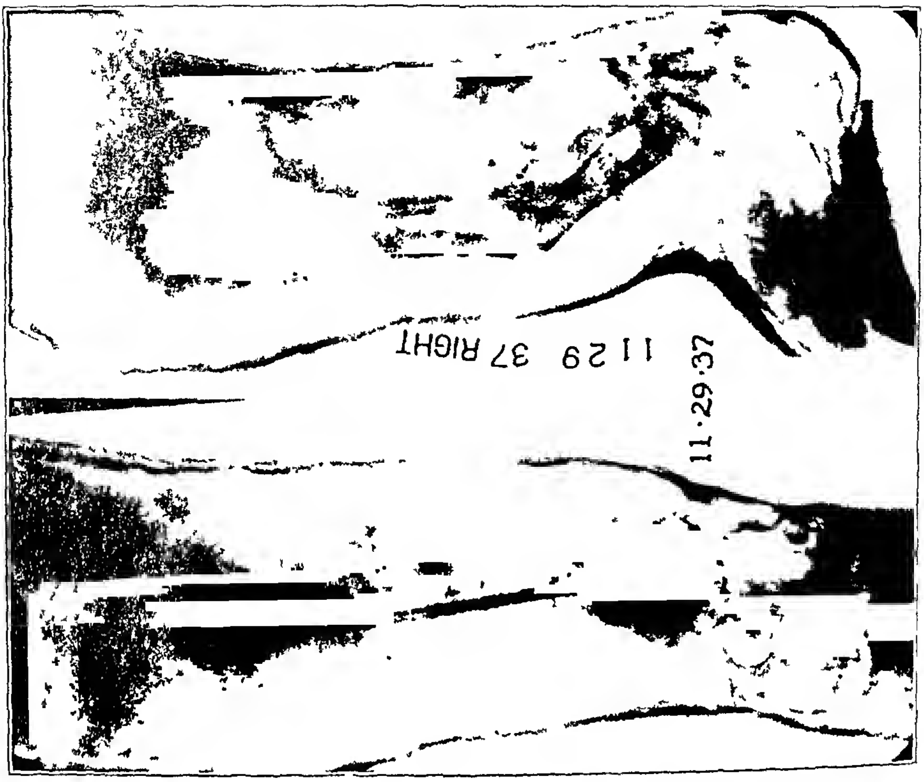

Fig 6-B
Case 1

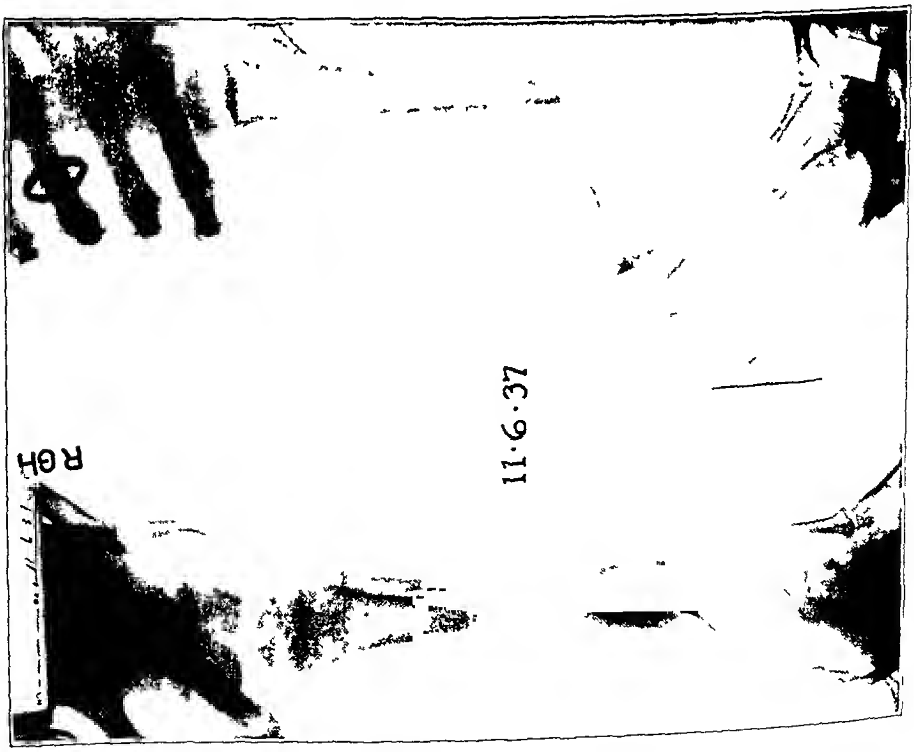

Fig 6-A
Case 1

Examination at this time showed marked anterior bowing of the bones of the leg with beginning tendency to ulceration of the skin over the sharp bony prominence, and abnormal mobility at the seat of fracture. Several small oval pigmented areas, characteristic of von Recklinghausen's multiple neurofibromatosis, were discovered on the skin of the trunk, but no family history of this condition could be elicited.

On November 26, 1937, both ends of the upper fragment of the fibula were transplanted into the tibia at the same time. The upper end was transplanted in the manner previously described; the pointed lower end extended only one centimeter below the pseudarthrosis and had to be lodged in a hole made in the upper end of the lower fragment. At the same time the sharp projecting ends of the tibial fragments were trimmed away. The leg was immobilized in a plaster casing.

Convalescence was uneventful, and roentgenographic examination in September 1938, showed both ends of the fibula united to the tibia with considerable hypertrophy of the fibula. There was no evidence of union at the point of pseudarthrosis, although by clinical examination the leg appeared quite solid. On December 9, 1938, the seat of fracture was exposed, and the tibial fragments were found to be united. The sharp apex of the angulated tibia was excised. Two bone grafts about two inches long and one-fourth inch wide were removed from the opposite tibia and layed on either side of the tibia under the periosteum. The leg was fixed in plaster. The girl made a normal recovery from the operation. In June 1939, the condition was satisfactory. The union appeared strong both clinically and roentgenographically.

When last seen in March 1940, she was getting about well in her brace. The deformity of the bones of the leg was not excessive, and there was shortening of two and five-tenths centimeters.

Case 5. P. C. (No. H13-934). A male, aged two years, was admitted to the Hospital for the Ruptured and Crippled in October 1934, with a diagnosis of congenital bowing of the right leg, pseudarthrosis of the tibia and fibula, and mental retardation. The child had first been seen at the hospital with this condition at the age of fifteen months. The leg had been continually immobilized in plaster for thirteen months without appreciable result. The roentgenographic examination showed marked bowing of the entire tibia and an ununited fracture of the fibula about half an inch above its lower end.

An operation was performed and the ends of the tibial fragments freed and stepped together with an overlap of three-fourths of an inch. The lower end of the upper fragment of the fibula was freed and transplanted into a hole in the

Fig. 6-C
Case 4

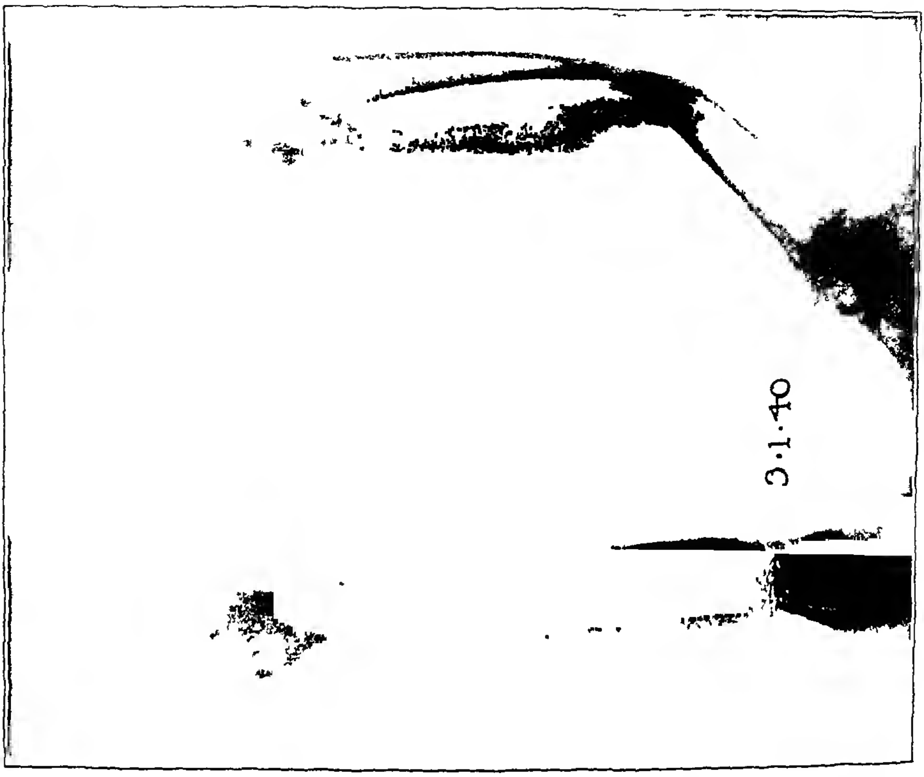

Fig. 6-E
Case 4

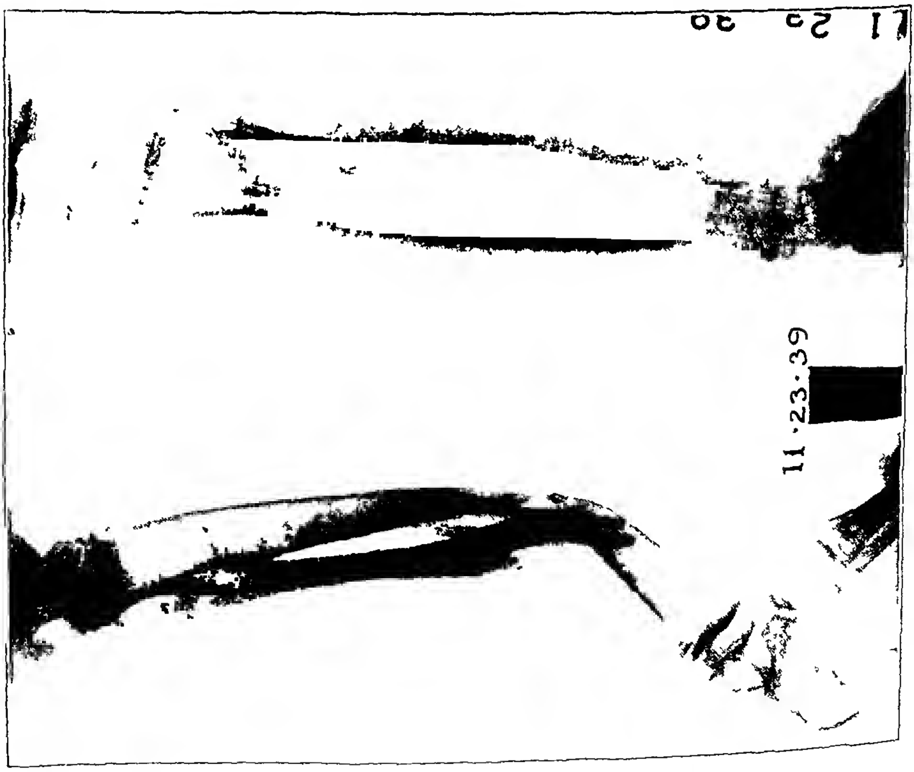

Fig. 6-D
Case 4

distal fragment of the tibia about one inch below the fracture, and a plaster casing was applied.

Six months postoperatively the roentgenographic examination showed that the fibula had united with the distal fragment of the tibia with anteromedial angulation, but the tibial fracture was still ununited. In April 1935, a second operation was performed in which a massive graft, three and five-tenths inches long, was removed from the opposite tibia, applied to the point of pseudarthrosis, and fixed with two steel screws.

The leg was immobilized in plaster until October 1935, at which time the roentgenographic examination showed solid union, and a long leg brace was fitted. He did well and was followed in the Out-Patient Clinic. In January 1937, the screws were found to be loose, and were removed. In May 1937, he complained of pain in his leg and the roentgenographic examination showed there had been a refracture of the tibia at the level of the previous pseudarthrosis. A close-fitting plaster casing was applied and worn continuously until March 1938, at which time there appeared to be a definite pseudarthrosis of the tibia. It was decided to transplant the upper end of the fibula into the upper end of the tibia.

This operation was performed on March 5, 1938, in the usual manner except that in order to bend the upper end of the fibula far enough inward to meet the tibia it was necessary to perform a partial osteotomy of the fibular shaft, and produce a green stick fracture. The leg was immobilized in plaster until January 1939, at which time the roentgenographic examination showed not only firm healing of both ends of the fibula with the tibia, but also bony union of the tibial pseudarthrosis.

When last seen in May 1940, he was getting about actively in his brace, and there were no complaints. Roentgenograms showed good healing of the tibia with anterior bowing, but there appeared to be a line of separation between the lower end of the fibula and the tibia.

Case 6. M. D. (No. H14-907). A female, negro, aged five years, was admitted to the Hospital for the Ruptured and Crippled in January 1938, with a diagnosis of congenital bowing of the right leg and pseudarthrosis of the tibia and fibula. She had been followed at the hospital since the age of one year, at which time she was found to have marked anterior bowing of the right tibia with pseudarthrosis of the fibula. In February 1934, an osteotomy of the tibia was performed with correction of the bowing followed by plaster immobilization. In November 1934, she was recognized as having a frank pseudarthrosis of both bones of the leg, and a long leg brace was fitted. In May 1935, the eburnated ends of the tibial fragments were excised, and a massive graft three inches long and three-fourths of an inch wide, taken from the left tibia, was fixed by the insertion of two steel screws. The ununited ends of the fibular fracture were overlapped about one inch, and the leg was fixed in a plaster casing. The child made a normal recovery, but rapid absorption of the graft occurred, and, in December 1935, it was evident that the condition of pseudarthrosis had been reestablished.

She was readmitted to the hospital for transplantation of the fibula, and the first stage of the operation was performed in February 1938, according to the method previously described. The incision was extended downward sufficiently to permit removal of the screws. Recovery was complicated by necrosis of a portion of one skin flap, but this was trimmed away and the wound healed by granulation. The second stage of the operation was performed seven weeks after the first, and considerable difficulty was experienced in establishing contact between the short upper fragment of the fibula and the lower fragment of the tibia. An attempt was made to fix them together with a chromic suture, but later it was found that the ends had separated. In October 1938, there was firm union of the upper end of the fibula to the tibia, but complete loss of connection at the lower end and the pseudarthrosis persisted. At this time the region of the pseudarthrosis and the lower end of the upper fibular fragment were exposed. The latter was osteotomized about two inches above its lower end, which permitted its insertion into a hole in the upper end of the lower tibial fragment. At the same time four slender, match-stick grafts, each about three inches long, were removed from the opposite tibia

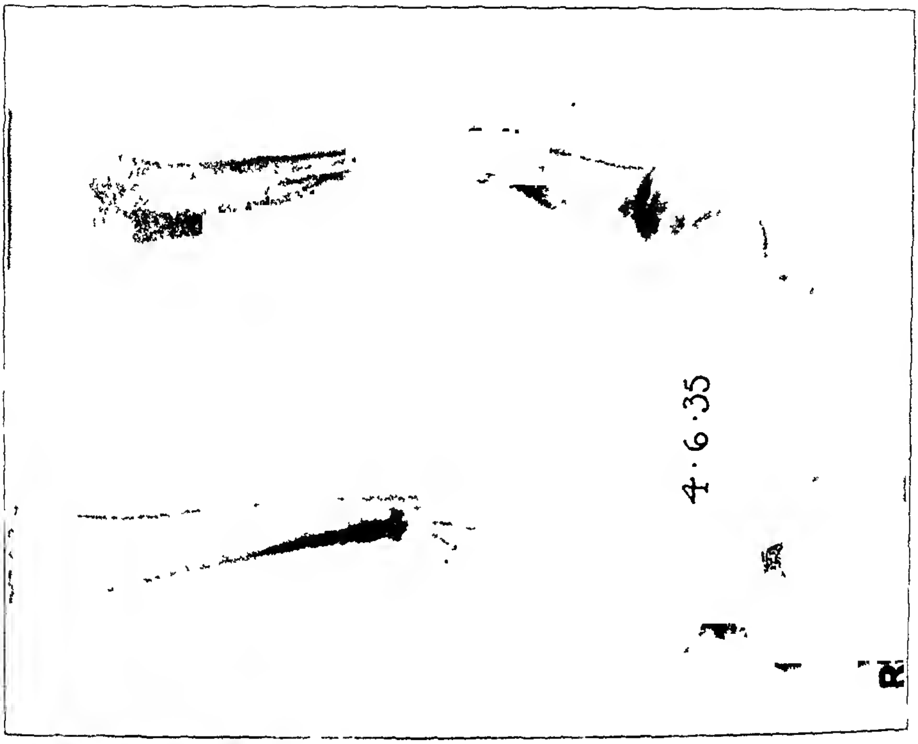

Fig 7-B
Case 5

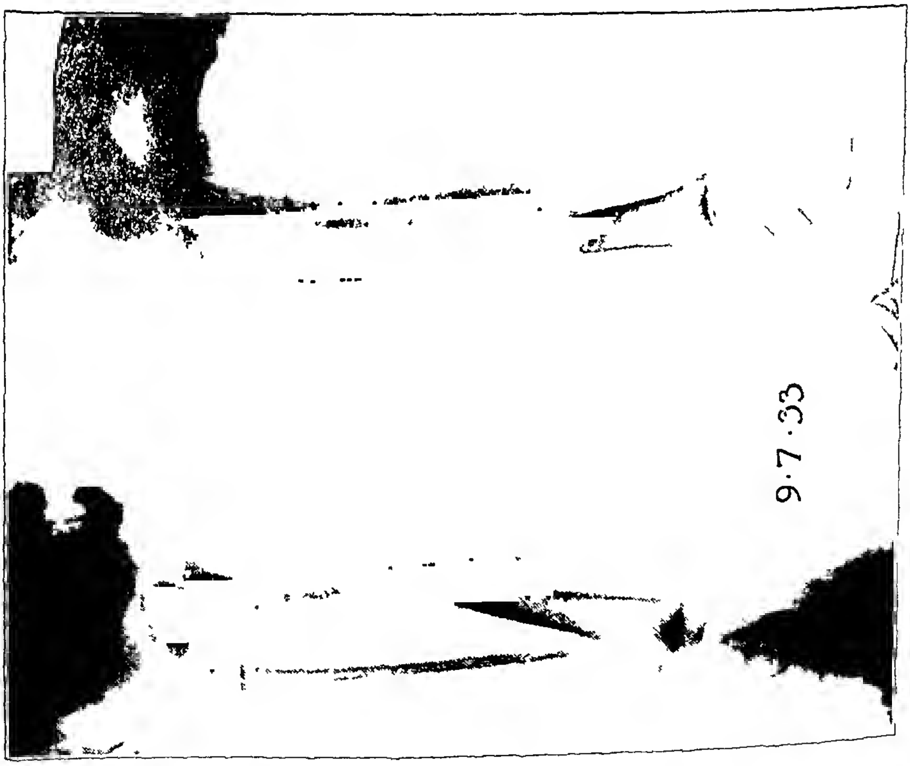

Fig 7-A
Case 5

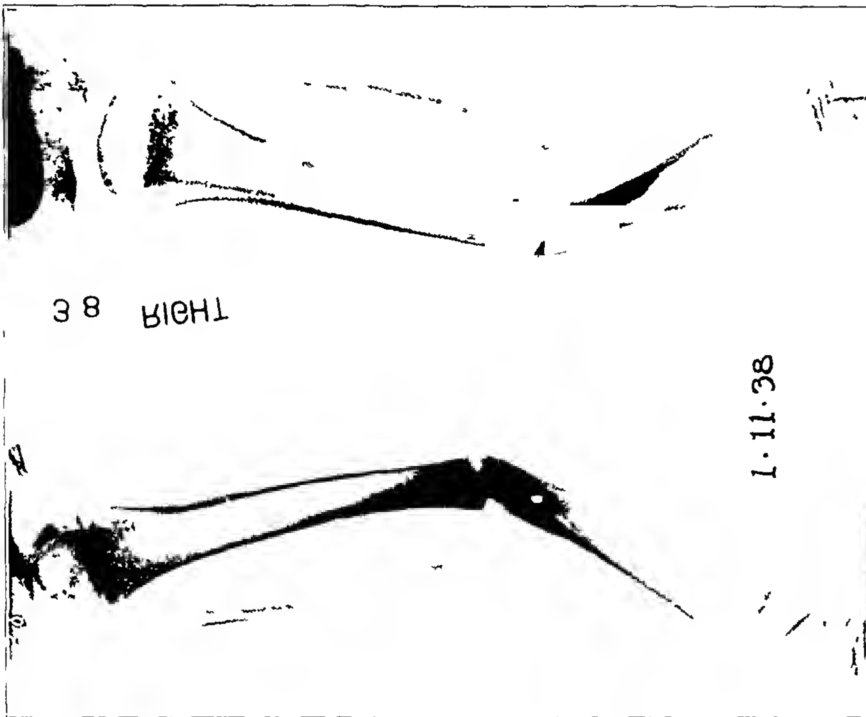

Fig. 7-D
Case 5

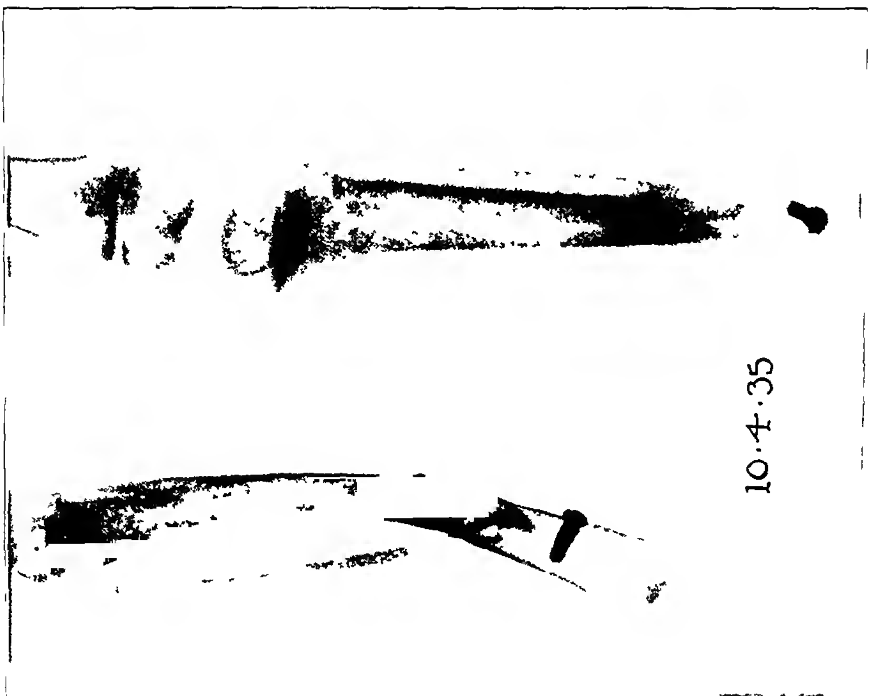

Fig. 7-C
Case 5

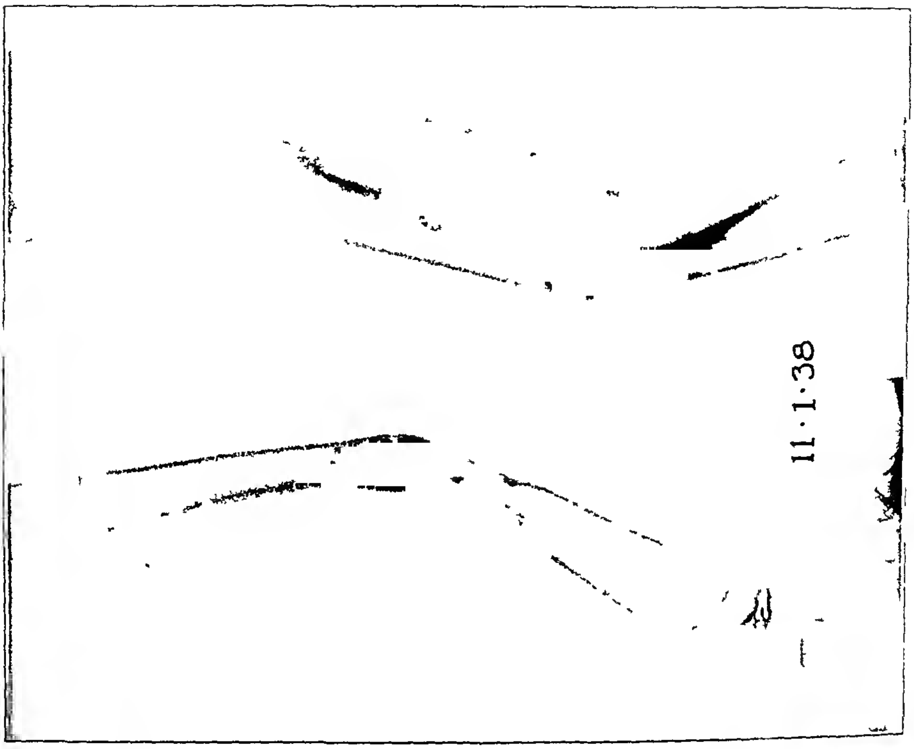

Fig. 7-F
Case 5

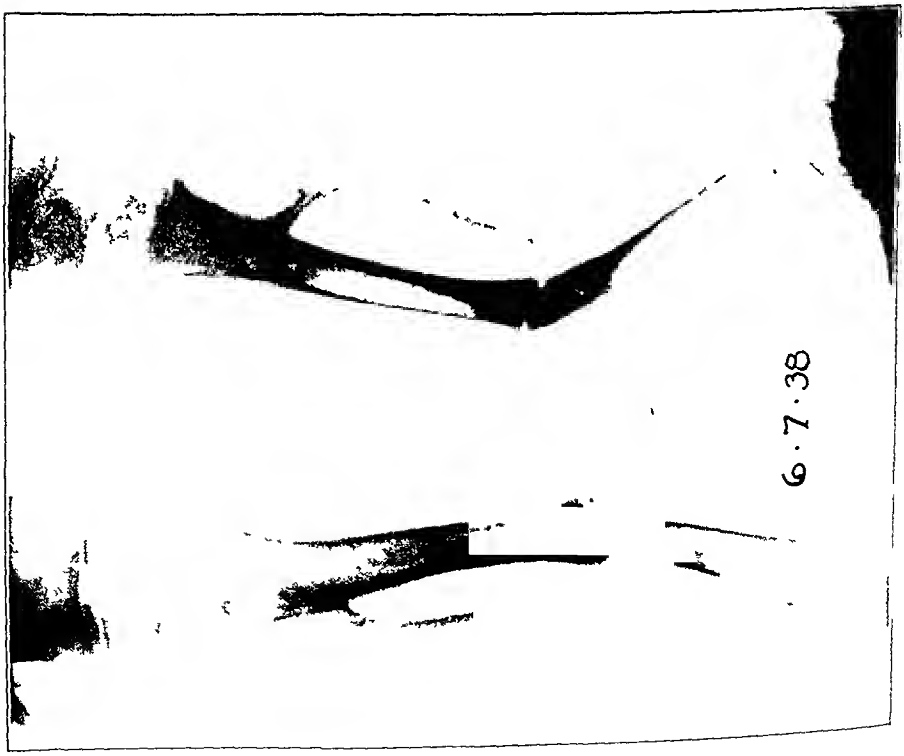

Fig. 7-E
Case 5

and laid under the periosteum about the point of the pseudarthrosis and at the junction of the fibular fragment with the tibia. The wound was closed and a plaster casing applied. Recovery was uneventful and two months later the roentgenographic examination showed a mass of new bone uniting the lower end of the fibula with the tibia. In November 1939, the fibula was found to be solidly incorporated in the tibia, and the tibial pseudarthrosis was also solidly united. At this time she was given a long leg brace and permitted to bear weight.

When last seen, in April 1940, she was getting about actively in her brace. The leg was straight with two inches of shortening. The union was solid on both clinical and roentgenographic examinations.

Fig. 7-G
Case 5

Case 7. D. R. (No. H30-147). A male, aged six years, was admitted to the Hospital for the Ruptured and Crippled in November 1938, with a diagnosis of congenital bowing of the left leg, and pseudarthrosis of left tibia and fibula. According to the parents, the deformity had been present from birth, but the boy was able to use the leg normally. About twelve weeks previously, he had fallen from a chair and fractured the leg. A plaster casing was applied, but when this was removed there was no evidence of union. Upon examination marked deformity of the leg with anterior bowing and abnormal mobility without pain could be demonstrated at the junction of the lower and middle thirds. The roentgenographic examination showed an ununited fracture of the tibia with medial and anterior angulation, and an ununited fracture of the fibula at a slightly lower level.

It was decided to transplant the upper fragment of the fibula. On November 4, 1938, the first stage of the operation was performed with transplantation of the upper end of the fibula into the lateral tuberosity of the tibia in the manner described. The second stage of the operation was performed on December 8, 1938, and the lower end of the upper fragment of the fibula was fixed to the lower tibial fragment with a wire suture. Both operations were followed by immobilization of the leg in a plaster casing.

Both ends of the fibula united promptly with the tibia, and, in March 1939, there was evidence that the tibial pseudarthrosis was uniting. A walking plaster was used for fixation until March 1940, at which time he was given a long leg brace. At this time he had normal use of the leg and the roentgenographic examination showed solid union of the tibia.

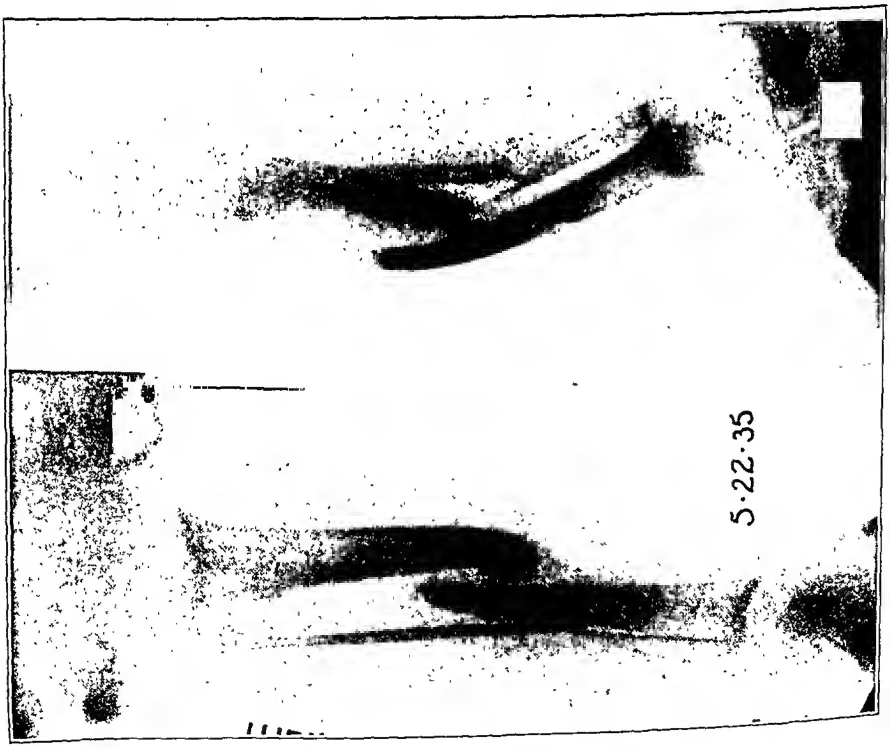

Fig. 8-A
Case 6

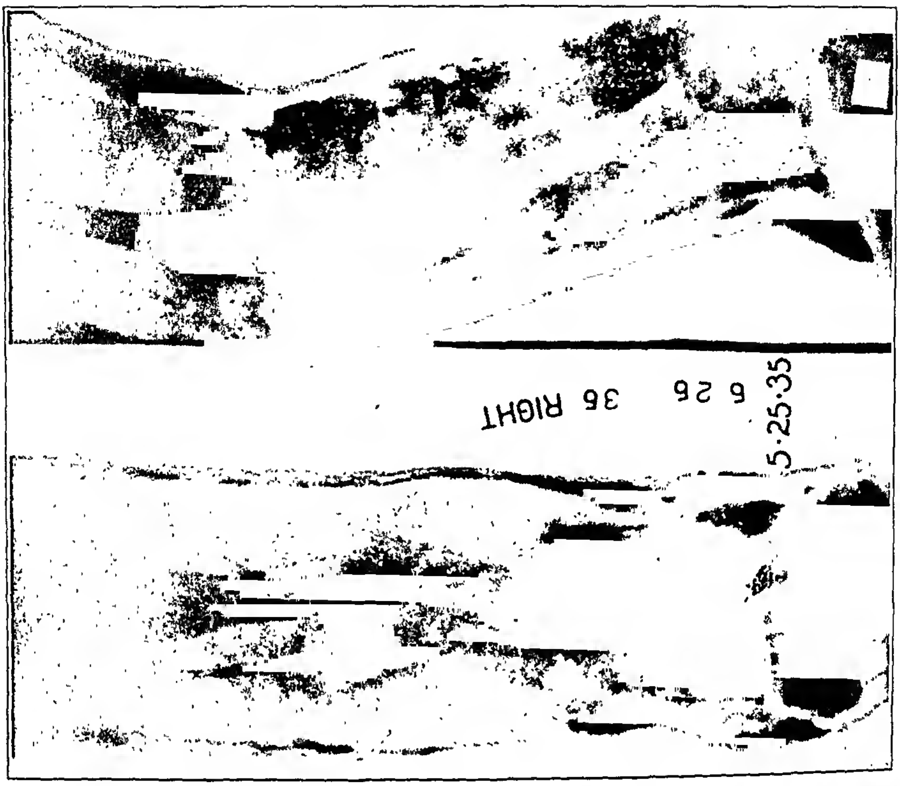

Fig. 8-B
Case 6

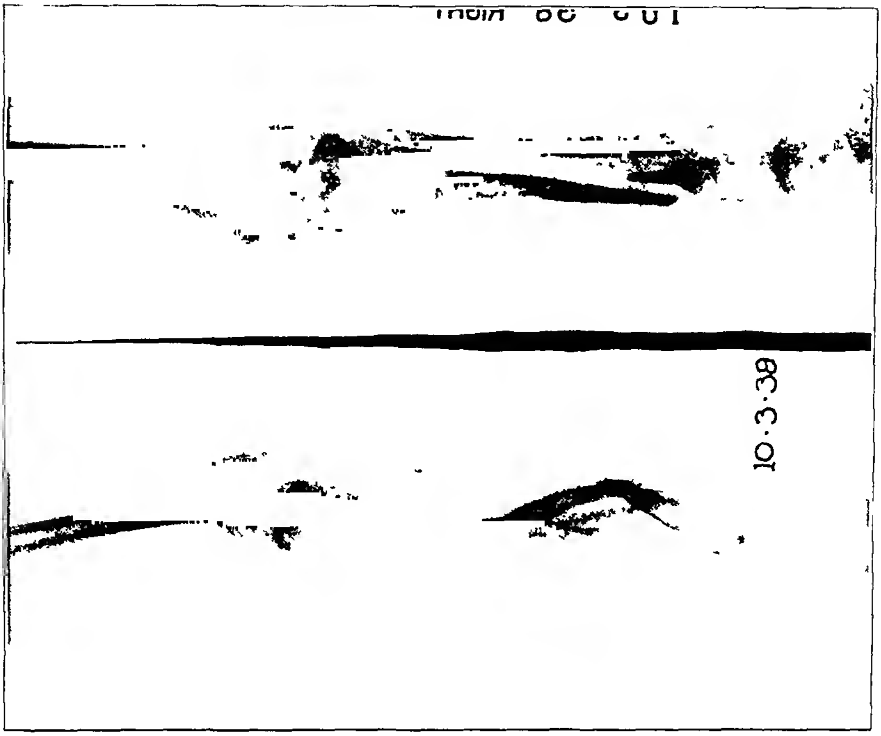

FIG. 8-D
Case 6

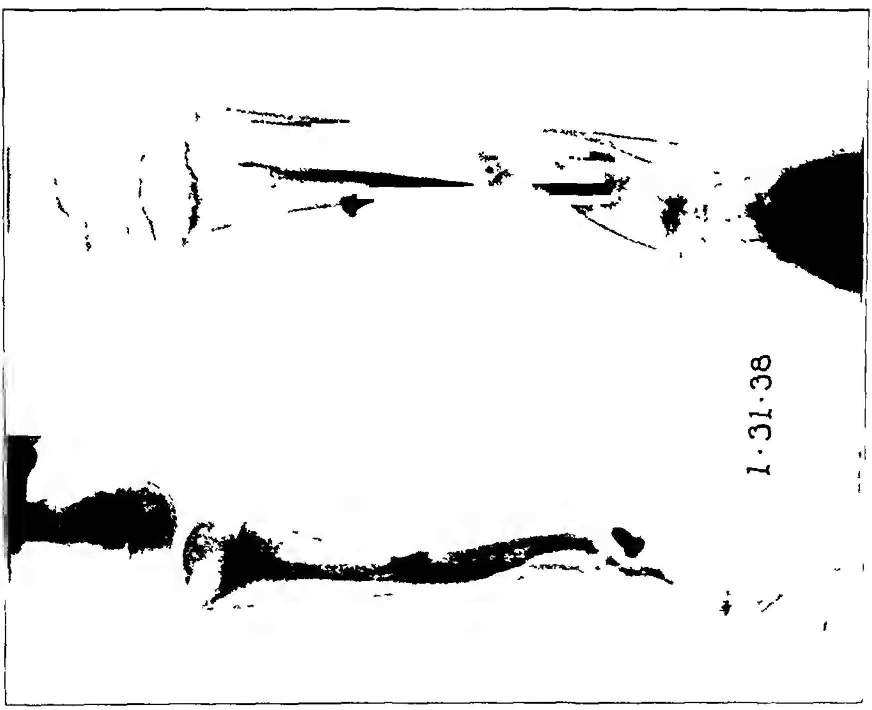

FIG. 8-C
Case 6

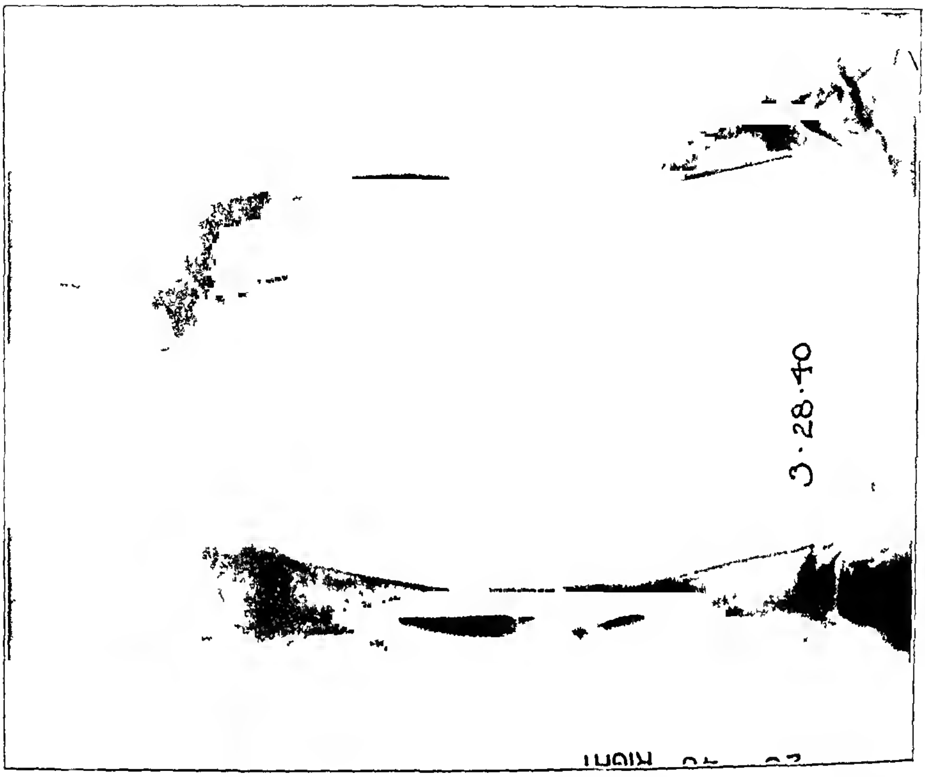

Fig 8-F
Case 6

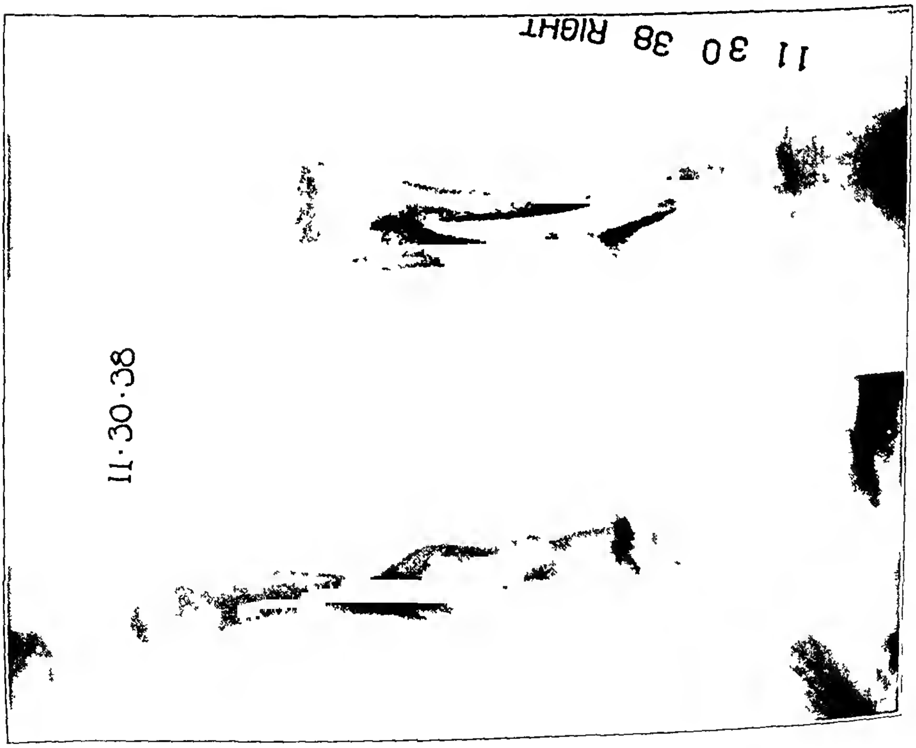

Fig 8-E
Case 6

CASE 8. F. L. (No. 1128-247). A male, aged forty-nine years, was admitted to the Hospital for the Ruptured and Crippled September 19, 1938, with a diagnosis of old, infected, compound fracture of both bones of left leg, and pseudarthrosis of the tibia. He had been injured in an automobile accident in June 1936. The fracture had been treated by skeletal traction, followed by a long period of immobilization in plaster. The wound healed after about four weeks. The fracture failed to unite, and in January 1937, an operation was performed, probably a bone transplantation from the same tibia, which was followed by wound infection and suppuration. The wound drained until February 23, 1938, when an operation was performed and a sequestrum removed. The wound healed by granulation and was completely closed at the end of four months. At this time a long leg brace was fitted and weight-bearing was encouraged.

The examination at the time of admission showed good alignment of the leg, shortening of about three-fourths of an inch, and abnormal mobility in the middle third of the tibia. The roentgenograms showed a gap of nearly one inch between the ends of the fragments of the tibia, and considerable eburnation. The fibula had been fractured, but had united.

Because of the history of recent infection it was thought that a bone-grafting operation had little chance of success, and a two-stage transplantation was advised. The first operation was performed on September 21, 1938, and consisted of excising the cartilaginous surfaces of the upper tibiofibular articulation, and burying the upper end of the fibula in a bed dug out of the lateral tuberosity of the tibia. The second stage was performed on October 17, 1938, when the fibular shaft was divided in its lower third, and its lower end applied to the lower fragment of the tibia where it was fixed with a vitallium screw. The leg was immobilized in plaster until March 1939, when the patient was allowed to resume wearing his brace.

Solid union of both ends of the fibula with the tibia was obtained, but there was still slight mobility of the tibia at the point of pseudarthrosis, and he was not able to walk without his brace. There had been no recurrence of the infection, and it was considered safe to do a bone-grafting operation, which was performed on June 15, 1939. A bone graft, six inches long, was removed from the opposite tibia and applied to the ends of the fragments,

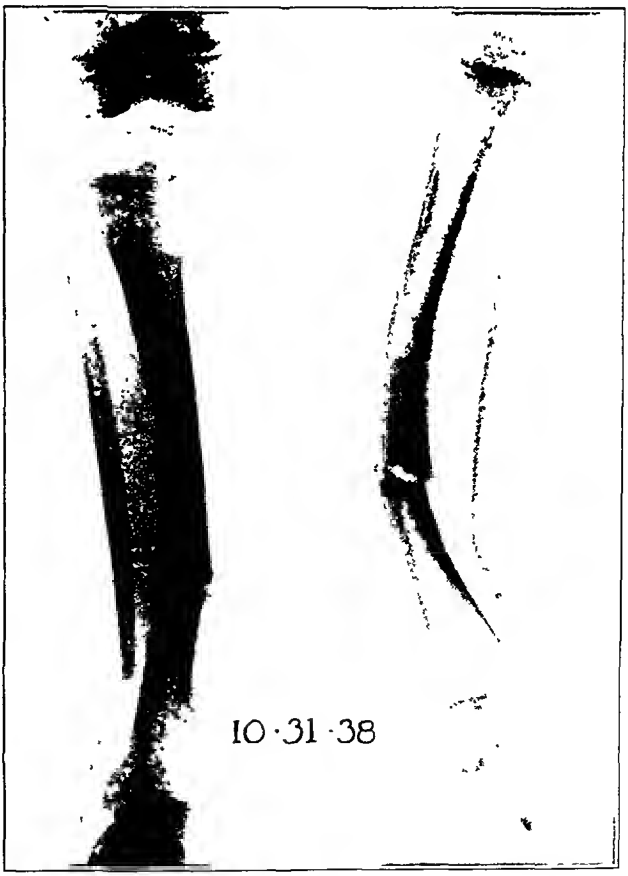

FIG. 9-A
Case 7

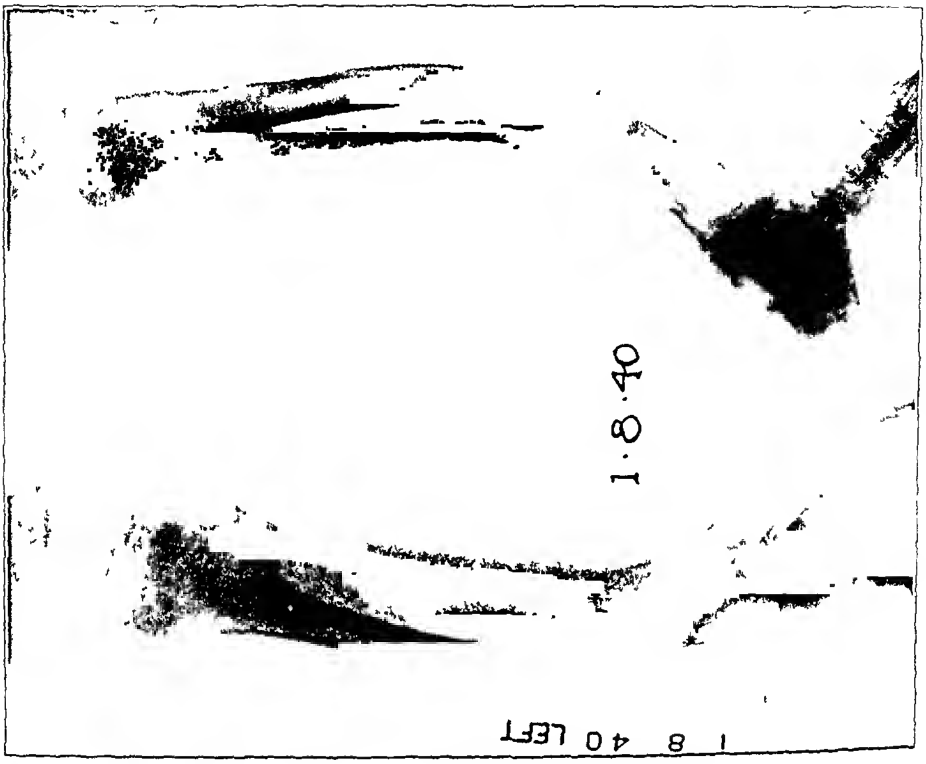

Fig. 9-C
Case 7

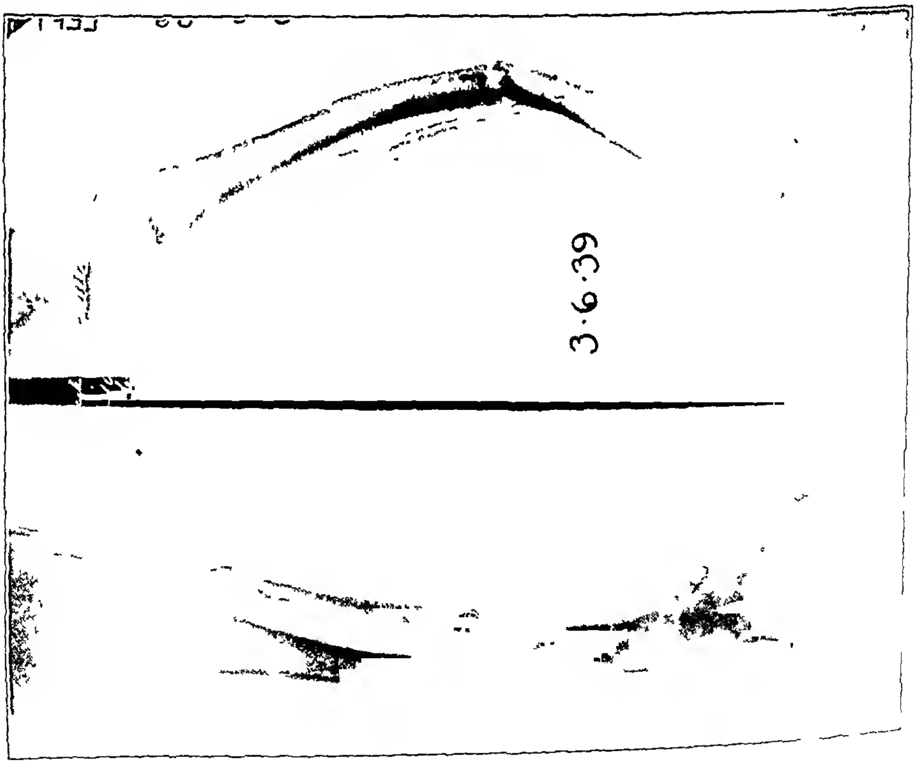

Fig. 9-B
Case 7

being fixed by the insertion of four vitallium screws. Recovery was complicated by a skin slough, about one inch in diameter, which was finally closed, except for a small persistent sinus, by the application of small pinch grafts. The leg was protected in a plaster-of-Paris casing, and later in a steel brace until January 1940, at which time the roentgenogram showed solid incorporation of the graft, and he was allowed to walk without support.

When last seen, in July 1940, he was walking without cane or other support, and there was solid union both clinically and roentgenographically. The leg was straight with shortening of three-fourths of an inch. There was still a small draining sinus on the medial surface which, on probing, led down to bare bone, and the roentgenogram suggested the presence of a small sequestrum in this region.

CASE 9. J. V. (No. 1131-136). A male, aged thirty-nine years, was admitted to the Hospital for the Ruptured and Crippled March 17, 1939, with a diagnosis of infected fracture of the bones of the right leg, and pseudarthrosis of the right tibia. The injury occurred March 14, 1938, when he was knocked down by a motor car. The fracture was not compound, and he was treated in splints for one month, when a bone-plating operation was performed, and the leg immobilized in a plaster casing. Infection developed and at the end of three months the plate was removed. The fracture failed to unite, and in November 1938, a third operation was performed, and the fragments were fixed together with wire.

Examination at the time of admission revealed a suppurating wound, one inch in diameter, situated over the medial surface of the middle of the tibia, and abnormal mobility of the tibia at this point. The leg showed moderate lateral bowing, and there was shortening of three-fourths of an inch. The roentgenograms showed an ununited fracture of the tibia in its middle third with a number of turns of wire in the ends of the fragments, and a loose sequestrum.

On March 24, 1939, the sequestrum and wire were removed, the wound was packed open with vaseline gauze, and a plaster casing was applied. On April 22 the wound was clean and granulating, and it was considered possible to block it out of the field and proceed with a two-stage transplantation of the fibula into the tibia.

The first stage of the operation was performed on April 29 and the second stage on June 14, each time followed by the application of a plaster casing. No complication occurred, and the wound over the tibia was completely healed in September 1939. At this time the man was fitted with a long leg brace and allowed to bear weight. The roentgenographic examination indicated that union at the lower end of the fibula was firm, but at the upper end it was questionable. There was evidence of beginning union of the pseudarthrosis. In December 1939, the roentgenograms showed solid union of the tibia and the brace was discontinued. When last seen in March 1940, he had no complaints and was walking with full weight on the leg. There was slight lateral bowing, but good function of the knee and ankle.

DISCUSSION

The point of chief interest that emerges from the study of the cases was the high proportion in which spontaneous union of the tibial pseudarthrosis followed promptly after the union of the fibula to the tibia. This occurred in six out of the nine cases. In two of these it was found advisable later to reinforce the union with sliver bone grafts, in one (Case 3) because of refracture, and in the other (Case 4) because of the delicacy of the bones, but this did not alter the fact that union had resulted. In two of the three cases in which union did not occur, there was a loss of substance in the tibia, and bony healing could not be expected. In the third case, which was one of congenital pseudarthrosis (Case 6), the upper

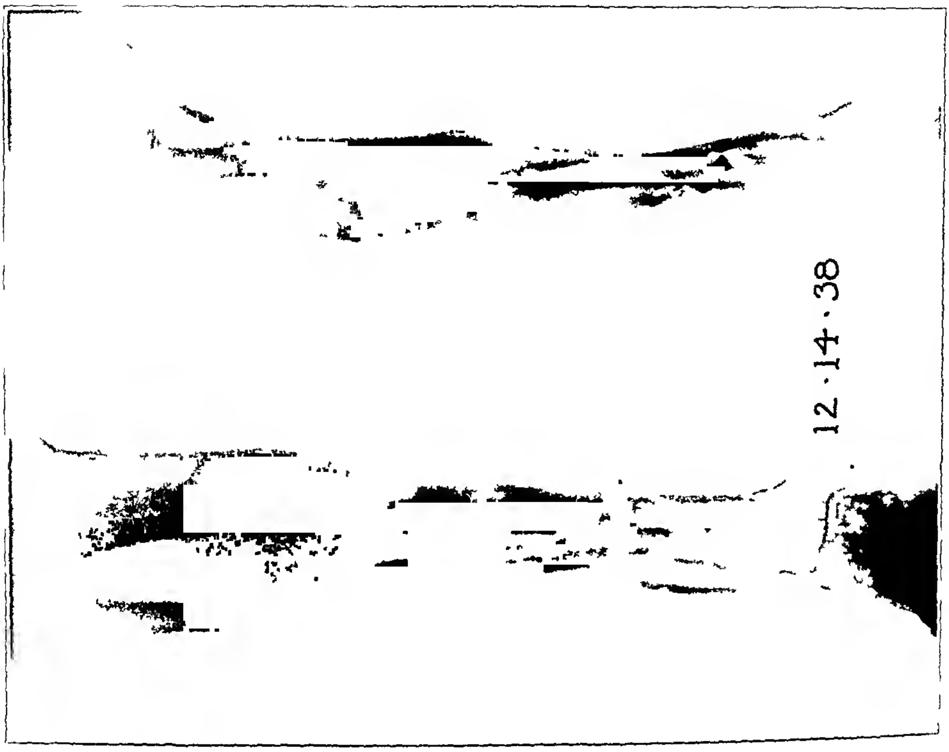

Fig. 10-B
Case 8

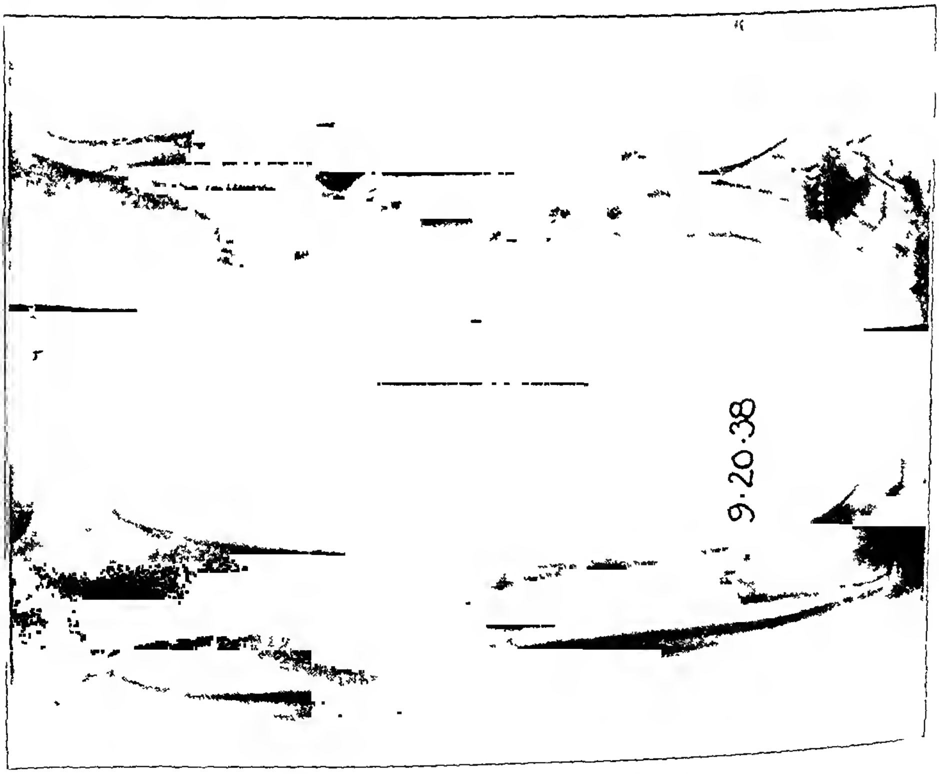

Fig. 10-A
Case 8

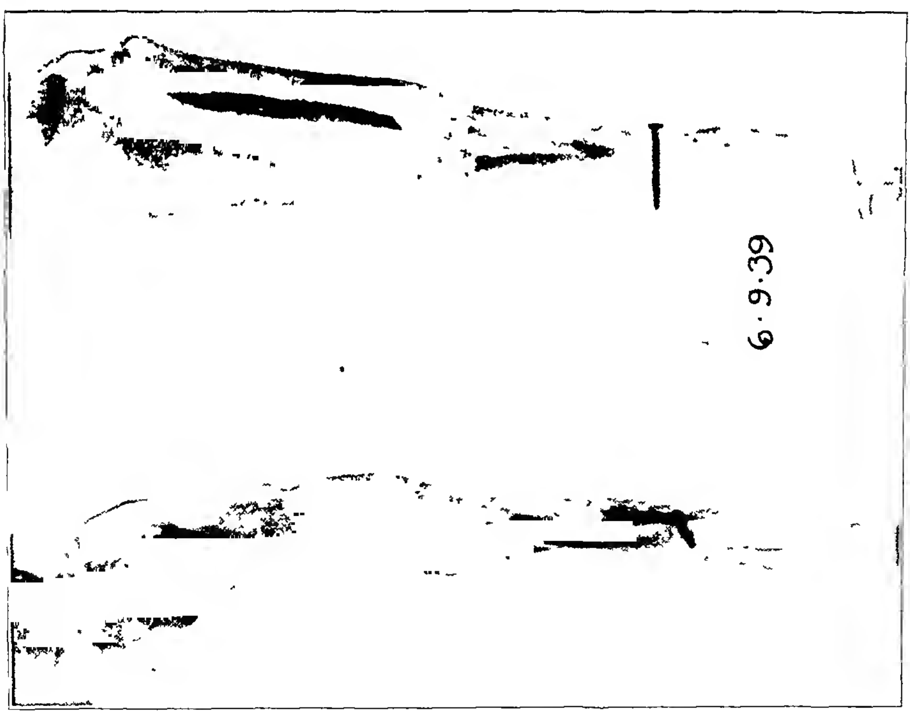

Fig. 10-C
Case 8

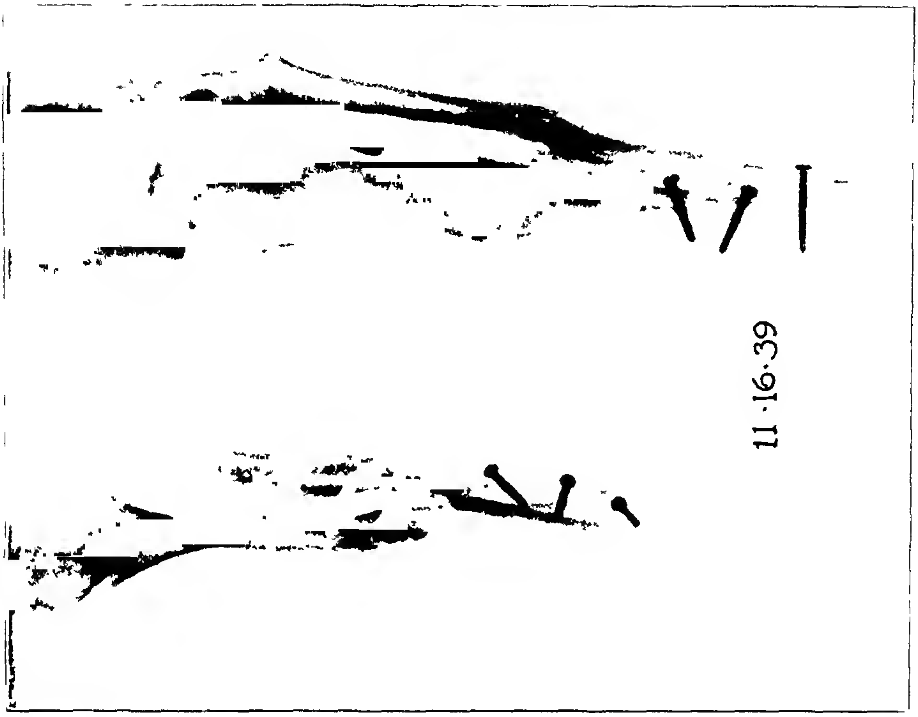

Fig. 10-D
Case 8

fibular fragment was too short to be approximated successfully to the lower tibial fragment, and bone grafts had to be employed to bring about a junction. Union developed promptly, but the roentgenograms leave some doubt as to whether the union of the tibia was secondary to the fibular transplantation or the result of contact with one of the bone grafts.

The author can only attribute this spontaneous healing of the pseudarthrosis to the internal splinting action of the fibular strut. He believes it affords further confirmation of the old principle that bony healing will take place when there is complete and rigid immobilization.

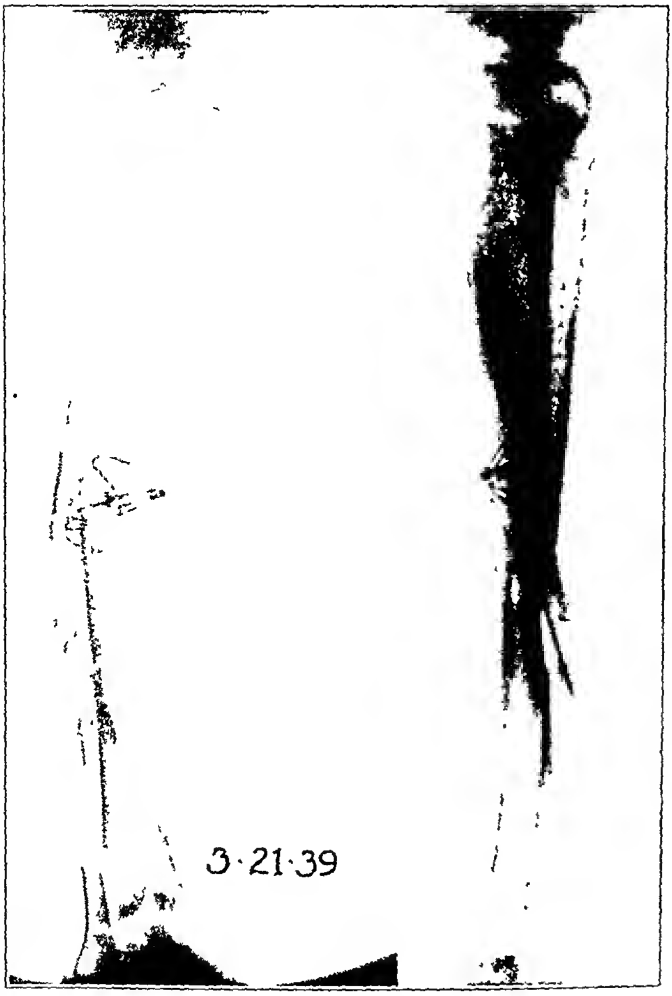

Fig. 11-A
Case 9

The question may be asked why not excise the articular cartilage at the superior tibiofibular joint and obtain the fusion of the upper end of the fibula there, instead of performing the more complicated operation described. In reply, it can be pointed out that in the case of children this could not be done without danger of causing serious distortion of epiphyseal growth. In the adult cases it is doubtful if it would be equally effective in bringing about tibial union, because the fibula being flexible, and the point of junction higher on the tibia than with the method described, there is greater likelihood of movement at the tibial pseudarthrosis. Demonstrable mobility of the tibial fragments was noted in two cases where this method was employed,—one, Case 8 of this series, and the other, the work of another surgeon.

In two of the cases in which fibular transplantation was done, there was bone infection at the point of pseudarthrosis, and draining sinuses, and in one other, although the wound was healed, infection had been

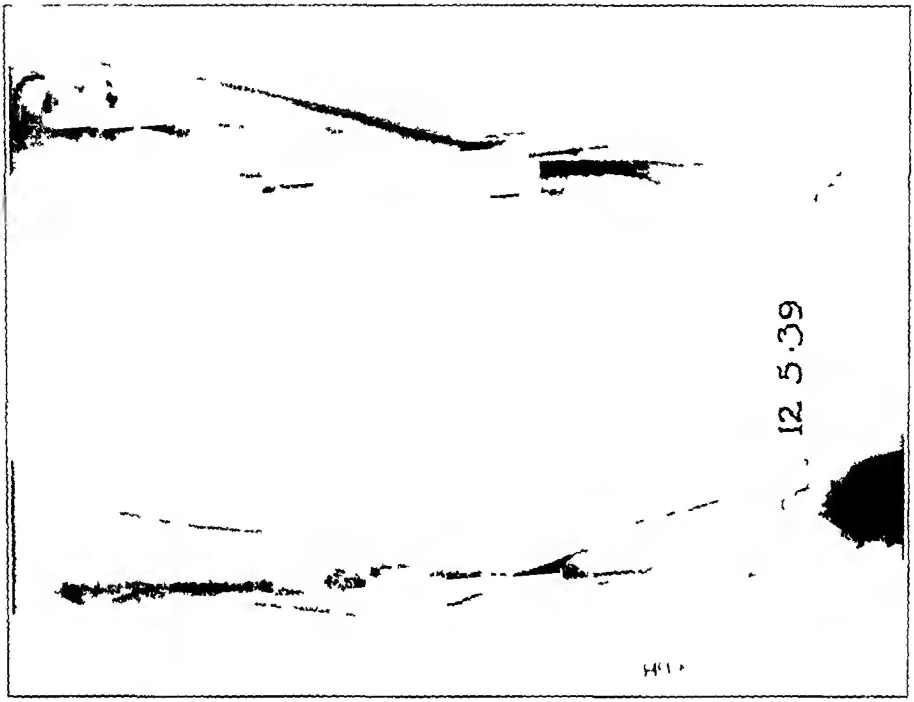

Fig 11-C
Case 9

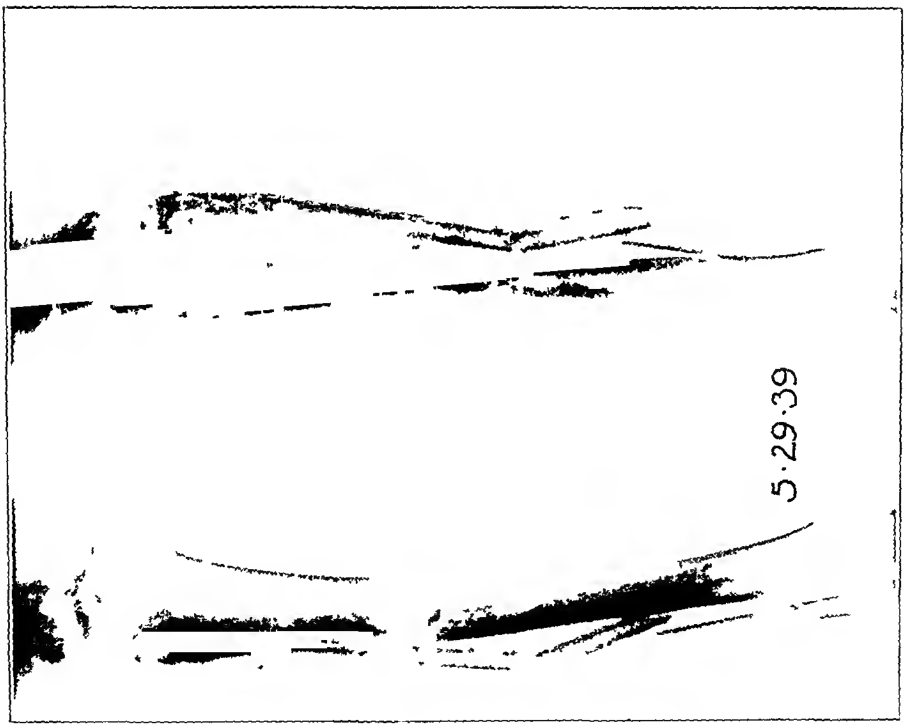

Fig 11-B
Case 9

TABLE I

SUMMARY OF CASES

Case No.	Name	Age at Operation	Previous Bone Grafts	Infections	Union After Transplantation: Upper End of Fibula	Union After Transplantation: Lower End of Fibula	Union After Transplantation: Pseudarthrosis	Later Bone Grafts: Purpose	Later Bone Grafts: Result
1	A.N.	35	2	No	Yes	Yes	Yes		
2	M.D.	24	0	Yes	No *	Yes	Yes		
3	D.S.	8	2	No	Yes	Yes	Yes	Reinforcement.	Union
4	E.G.	5	0	No	Yes	Yes	Yes	Reinforcement.	Union
5	P.C.	6	1	No	Yes **	Yes †	No	Non-union of tibia.	Union
6	M.D.	6	1	No	Yes	No	No	Non-union of tibia and reinforcement of tibial-fibular junction.	Union
7	D.R.	6	0	No	Yes	Yes	Yes		
8	F.L.	49	0	Yes	Yes	Yes	No	Non-union of tibia.	Union
9	J.V.	39	0	Yes	Yes	Yes	Yes		

* Union was later obtained after two further operations.

† The lower end of the upper fragment of the fibula was transplanted to the lower fragment of the tibia, and was later followed by a successful bone-grafting operation.

** Transplantation of the upper end of the proximal fragment of the fibula was made necessary by a refracture of the tibia.

present so recently that there would have been danger in attempting a bone-grafting operation. In all of these cases, fibular transplantation afforded the only safe solution of a problem that would otherwise have had to be postponed for many months.

SUMMARY

A simple method of two-stage transplantation of the fibula into the tibia has been used in nine cases of complicated pseudarthrosis. These included four adults of whom three had infected pseudarthrosis, and one uninfected, but with pseudarthrosis still present following two previous bone-grafting operations; and five children with congenital pseudarthrosis or pseudarthrosis resulting from operative correction of congenital bowing, in four of whom previous bone-grafting operations had been done with failure. Bony union of the pseudarthrosis developed spontaneously in six of these nine cases, and in the others supplementary bone-grafting operations resulted in success.

Fibular transplantation has a much wider application in the treatment of tibial pseudarthrosis than has been previously realized, and should not be reserved for those cases in which there are gross tibial defects. The method is worth consideration in cases of infected or complicated pseudarthrosis, and also in the congenital pseudarthrosis of childhood.

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SPONTANEOUS FRACTURE OF THE FEMORAL NECK FOLLOWING ROENTGEN-RAY THERAPY OVER THE PELVIS

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Spontaneous fracture of the femoral neck, following roentgen-ray therapy directed over the pelvis for the treatment of malignant disease, is fortunately an unusual complication of such treatment. It is sufficiently important, however, to warrant the consideration of those who use roentgen-ray therapy, and should be borne in mind whenever the dosage and the size and position of the portals are being planned for the treatment of malignant disease within or about the pelvis. Because there are relatively few reports in the literature concerning spontaneous fracture of the femoral neck following roentgen-ray therapy, and since there seems to be considerable variation in the incidence of this complication in large series of cases receiving roentgen-ray therapy over the pelvis, the experience regarding this entity is being reported with the hope that, as more data are gathered concerning it, the important factors regarding its cause will become apparent. Measures can then be taken more intelligently to guard against its occurrence in the future.

Although this entity was first reported in 1927 by Baensch[1], only a few case reports appeared in the literature until 1936 when Dalby, Jacox, and Miller reviewed a series of 471 patients who had received roentgen-ray therapy over the pelvis. In this group, there were ten cases of fracture of the femoral neck, an incidence of 2.1 per cent. In May 1939, Peck reported an incidence of 2.8 per cent. in 1026 cases of pelvic malignancy treated by roentgen-ray. These reports are quite interesting, not only because of the pathological material which was available for study, but also because of the high incidence of this complication following roentgen-ray therapy over the pelvis. It is not immediately apparent why the latter should be high in some clinics and low in others, where cases with the same types of pathology are treated with roentgen-ray therapy and are carefully followed afterwards.

A review of the cases of primary malignancy in the region of the pelvis, which were treated by roentgen-ray in this Hospital, revealed a total of 1084 cases between the years of 1927 and 1939. Some of these patients had both roentgen-ray therapy and radium, but others, who received radium alone, are not included in this series. In this entire group, there has been one case of fracture of the femoral neck without evidence of metastatic malignancy to account for the fracture, an incidence of .09 per cent. All other cases of fracture of the femoral neck have had roentgenographic findings characteristic of metastatic disease. In spite of its

rarity it is believed that the following case of fracture of the femoral neck is not due to metastatic disease, but to changes secondary to roentgen-ray therapy,—namely, fibrosis resulting in impaired blood supply and osteoporosis.

An American toolmaker, fifty-eight years of age, was first seen in the Out-Patient Department on September 1, 1937, because of a sore on the penis. He gave a history of having had a circumcision three years previously. Following this, there remained a small area near the fraenum which failed to heal. The patient neglected to have anything done about it until fourteen months before his visit to the Out-Patient Department. The lesion was then removed by his family doctor who told him that it was a cancer. Several months later, a recurrence appeared for which he received a few "electrical treatments". In spite of these, the recurrence rapidly increased in size, and, at the time of his visit to the Out-Patient Department, was causing considerable pain in the penis and perineum.

The past history, marital history, and family history were essentially negative, except that his father died of carcinoma of the throat.

Physical examination showed a well-developed, well-nourished man of fifty-eight with good color. Heart, lungs, and abdomen were essentially negative. A firm node could be felt in the right inguinal region, the nature of which was questionable, because of extensive infection in the ulcerating new growth involving the penis. The glans was almost completely eroded by the tumor, which also extended a short distance along the shaft of the penis. The scrotum was negative to examination.

The patient was admitted to the Hospital at once. After a period during which antiseptic dressings were applied to the ulcerating area on the glans, a radical amputation of the penis was done, and the urethra was transplanted to a perineal opening. Following a satisfactory postoperative convalescence, he was given a series of roentgen-ray treatments consisting of 1600 roentgen units to each groin through portals, ten by fifteen centimeters, over each groin. He received 400 roentgens at each treatment from a 200-kilovolt machine, with .5 millimeters of copper for filtration at a distance of fifty centimeters. He was discharged on October 28, 1937.

The patient was followed in the Out-Patient Department, and, when seen there on February 9, 1938, about four months after his discharge from the Hospital, his only complaint was pain in the left leg, aggravated by weight-bearing. Examination of the operative scars and groins showed no evidence of recurrence, and the perineal urethral opening was functioning well. A roentgenogram of the patient's left hip at that time revealed evidence suggestive of a fracture of the neck of the left femur with slight deformity (Fig. 1). The duration of this fracture, however, could not be determined by the roentgenographic findings. When the patient was next seen in the Out-Patient Department on October 19, 1938, eight months later, he was walking with the aid of two canes, and had a considerable limp. On examination, he was found to have limitation of motion of both hips, more marked on the left, and spasm about the left hip. Again there was no evidence of recurrence in the region of the operative scars or in either groin. Roentgenograms of the pelvis and both hips showed marked arteriosclerosis and generalized osteoporosis. There was further rarefaction of the left femoral head and neck, and no evidence of callus formation at the fracture line (Fig. 2). A fracture had also occurred in the right femoral neck, but there was slight evidence of healing with a coxa varus deformity.

The patient was admitted to the Hospital for the second time on October 23, 1938, for further study. Roentgenograms of the patient's skull, chest, and extremities, with the exception of the right tibia, were essentially negative. In the upper portion of the right tibia a small, elongated cavity was found. This contained irregular areas of calcification, suggesting an old healed osteomyelitis with small sequestra.

Laboratory studies of the patient's blood revealed a slight secondary anaemia. The blood calcium was 10 milligrams per 100 cubic centimeters of blood and the phosphorus, 3 milligrams per 100 cubic centimeters of blood. The blood Wassermann was negative.

FIG. 1

Spontaneous subcapital fracture of the left hip following roentgen-ray irradiation to the pelvis

FIG. 2

The same hip eight months later, showing an obvious fracture, radiation osteonecrosis, and rarefaction of the femoral neck and head.

Fig. 3

Taken April 2, 1941, showing no metastasis. Progressive absorption of the head of the femur on the left has left the end of the nail uncovered. Corrective measures are being considered to prevent further erosion of the acetabulum. The old fracture of the right femoral neck, which healed with a coxa varus deformity, can also be noted.

It became apparent, therefore, that the patient had no marked generalized disturbance of calcium and phosphorus metabolism, and that the osteoporosis was chiefly limited to the bones of the pelvis and upper femora.

The patient was seen by an orthopaedic consultant who advised the insertion of a triflanged nail in the left hip, since there was no evidence of healing. This was done at the Massachusetts General Hospital. During his convalescence, repeated blood calcium and phosphorus determinations were again essentially normal. The quantitative twenty-four-hour output of calcium in the urine, while the patient was on a low-calcium diet, was also normal. He was finally discharged from the Hospital on February 19, 1939. At that time, he was able to get about quite well with the slight aid of crutches.

The marked degree of localized osteoporosis can be seen in the photographs which show the hip before the nail was inserted (Figs. 1 and 2).*

The patient has returned periodically to the Out-Patient Department. On November 11, 1939, he was still using crutches some, and walked with a definite limp. His general condition, however, was good and there was no evidence of recurrence either in the groin or in the region of the operative scar. Roentgenograms of both hips showed a persisting slight coxa varus deformity of the right femoral neck. There was no evidence of callus formation about the fracture in the left femoral neck.

He was last seen on April 2, 1941, three and one-half years after his first operation at this Hospital. No evidence of recurrent malignancy was found either in the region of the operative scar or in the groin. Roentgenograms of the patient's pelvis and hips (Fig. 3) show the coxa varus deformity of the right femoral neck. Following the insertion of the Smith-Petersen nail, about twenty-nine months ago, the femoral head was fixed so as to permit weight-bearing on the normal joint surfaces. Since then the upper portion of the femoral head has undergone further absorption, thereby leaving the upper aspect of the

* These photographs were loaned to and used by Batt and Hampton.[3]

inner end of the nail uncovered. As a result of this, the nail impinges on the acetabulum causing erosion of its upper surface as the patient walks. The patient, however, gets around surprisingly well.

There has not yet been opportunity to study microscopically the changes present in the femoral neck which fractured following radiation. However, in view of the changes known to occur in tissues following radiation, it would appear logical that fibrosis and decreased vascularity might also occur in bone following roentgen-ray therapy. Furthermore, when a patient already has marked arteriosclerosis, with changes in the larger vessels which can be visualized by roentgen-ray, it would seem likely that additional damage to the walls of the smaller arteries, such as thickening and hyalinization following radiation, would seriously impair their function, if not actually occlude them. According to Dalby, Jacox, and Miller, who have had pathological material to examine in such cases, these changes do occur. Because the blood supply to the femoral neck is relatively vulnerable, particularly in older people, radiation changes might be expected to result in serious impairment of the nutrition of this structure with such secondary effects as osteoporosis. Fracture of the femoral neck could then be expected without trauma. It is of interest to note that there was no history of trauma in the case just reviewed, or in most of the cases reported by Dalby, Jacox, and Miller.

In view of the incidence of fracture of the femoral neck, 2.1 per cent., as reported by Dalby, Jacox, and Miller in their series of 471 cases, it is surprising that this entity has not been reported more often by other clinics where large numbers of cases are treated. A review of the technique of roentgen-ray treatment at this Hospital reveals that the roentgen-ray portals are seldom large enough or so placed as to include the region of the femoral heads and necks. The cases of pelvic malignancy which are treated with roentgen-ray therapy are usually given treatment through four pelvic portals not larger than ten by ten centimeters, and are placed near the mid-line. Formerly two large portals twenty by twenty centimeters, one anteriorly and one posteriorly, were used. Occasionally a perineal portal not larger than ten by ten centimeters was used. The dosage depends on the location and nature of the malignancy, but seldom exceeds 1800 roentgens per portal during one series of treatments. The use of a 200-kilovolt machine with a filtration of .5 millimeters of copper at a distance of fifty centimeters is the standard technique.

In the case just reviewed, it will be noted that the patient received a total of 1600 roentgens through each of two portals, ten by fifteen centimeters, and, furthermore, that these portals were located over the groins. Inasmuch as there are many other cases in the total group that received roentgen-ray treatment over the groins in equal or larger doses without apparent change in the femoral neck, one is not justified from these data, in assuming that the pathological changes are entirely due to changes secondary to roentgen-ray *per se*. It would seem likely that the extent of vascular damage already caused by arteriosclerosis would be an

important contributing factor. It is conceivable, however, that large doses of roentgen-ray therapy, or repeated doses through portals including the femoral necks, would cause sufficient fibrosis eventually to give the same end result of osteoporosis and fracture. The failure of callus to form is not surprising in view of the marked vascular disturbance. A fibrous union does form, and apparently may become sufficiently strong to permit some degree of weight-bearing.

SUMMARY

1. The case of fracture of the femoral neck here reported is the first at this Hospital in a series of 1084 cases receiving roentgen-ray treatment over the pelvis, an incidence of .09 per cent.

2. The fracture resulted from weight-bearing in the presence of marked osteoporosis, developing in a bone whose blood supply had first been impaired by arteriosclerosis, and was then further damaged by roentgen-ray therapy and fibrosis.

3. At the present time, about three years since the fracture occurred, there has been no callus formation demonstrable by roentgenograms.

4. When roentgen-ray treatment is given over the pelvis, the portals should be placed so that they do not include the region of the femoral necks. If this is unavoidable, the portals should be as small as possible.

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SUBCLAVICULAR DISLOCATION OF THE OMOHYOID MUSCLE BY RUPTURE OF ITS BINDING FASCIA

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A thorough search of the literature has failed to show any case of dislocation of the omohyoid muscle by rupture of its binding fascia following an indirect trauma. A report of a case is, therefore, of interest.

H. B., a white male, forty years old, who was a sheet-metal worker, had noted a "lump in his left shoulder" about a week before examination. It was located in the posterior triangle of the neck. About a week earlier, he had been lifting a heavy piece of machinery and felt a snap in the shoulder, followed by immediate severe pain in the left shoulder and in the left side of the neck. During the next two days the pain gradually decreased until he became free of pain. A week after the injury, as he was shaving, he noticed a large lump above his left collar bone. The past history was irrelevant.

Directly above the middle of the left clavicle there was a mass, approximately three inches in diameter (Fig. 1). The function of the left upper extremity was unimpaired. There was no pulsation of the mass nor was there impulse on coughing. Inspiration caused no change in the size of the mass. It was soft and easily reduced. The absence of pulsation, thrill, or bruit eliminated the possibility of a traumatic aneurysm of the subclavian artery. Auscultation ruled out any pulmonary pathology.

It was particularly noticed that when the scapula was depressed by downward pull upon the slightly abducted and flexed arm, the mass disappeared (Fig. 2). The easily palpable edges of the trapezius and sternocleidomastoid muscles were found not to be involved. The only structure that would explain this phenomenon was the omohyoid muscle. A preoperative diagnosis of rupture of the omohyoid muscle and tear of the cervical fascia was made.

The patient was admitted to the New York Post Graduate Hospital on December 28, 1939. Under cyclopropane-oxygen anaesthesia, a curved horizontal incision was made in the base of the neck. This incision was placed about a fingerbreadth above the left clavicle and began at the posterior edge of the sternocleidomastoid muscle, and ran laterally toward the trapezius. The platysma was dissected through bluntly, and the supraclavicular fossa exposed. The supraclavicular nerves were identified and retracted. The patient was then forced by the anaesthetist to inhale strongly, which caused balloon-

FIG. 1

FIG. 2

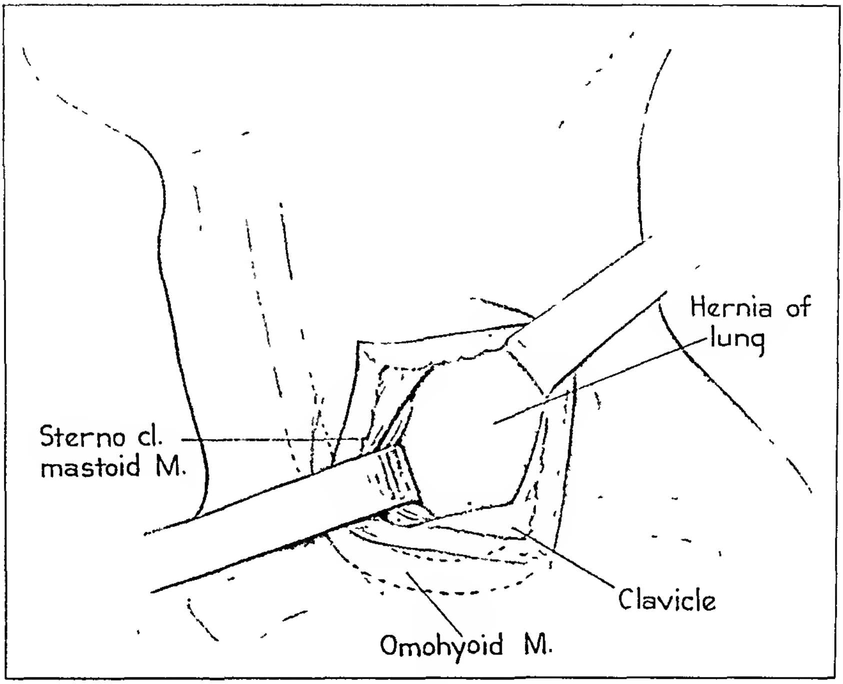

FIG. 3

ing of the apex of the lung which had protruded into the supraclavicular fossa. The omohyoid muscle was found, after long search, behind the clavicle, torn from its binding, deep cervical fascia. Sibson's fascia over the cupola of the lung was also torn (Fig. 3). The central tendinous part of the omohyoid muscle was sutured to the cervical fascia near the apex of the lung, restoring the angle of the omohyoid. The tissues over the apex of the lung were reinforced by suture. The wound was closed in layers and a rubber drain inserted superficially.

The postoperative course was not eventful and the patient was discharged on the second postoperative day with the left arm in a sling.

A biopsy of the adjacent trapezius muscle showed muscle fibers closely packed in bundles. They were in part normally striated, and in part homogeneous and hyaline. Some showed basophilic staining and some necrotic nuclei with fine-stippling, with here and there extravasations of blood, indicating traumatized and degenerated muscle.

The immediate end result of this case was satisfactory. The patient has no disability at the present time although he is conscious of a small bulge in the supraclavicular fossa. This is visible to the examiner, but is very much smaller than the original mass. He returned to heavy work about two and one-half months after the operation. The overlying scar in the neck is rather dense and adherent to the underlying structures.

SUMMARY

A hitherto unrecorded subclavicular dislocation of the omohyoid muscle by rupture of its binding fascia, following indirect trauma, is reported. The apex of the lung bulged into the supraclavicular fossa on inspiration because its covering cervical fascia had been torn. In the differential diagnosis, it is absolutely necessary that aneurysm of the subclavian artery be ruled out. It is a tribute to the strength and binding power of the deep cervical fascia, as of all deep fascia, that it is so seldom torn by indirect violence.

GIANT-CELL SYNOVIAL TUMOR OF THE KNEE

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Solitary tumors of the articular structures of joints are comparatively rare and a preoperative diagnosis is seldom made. De Santo and Wilson[1] have recently reviewed 109 cases of tumors of the synovial membrane and found only five of the giant-cell variety. This neoplasm is regarded as benign, but local recurrence may take place and postoperative radiation should be advised.

CASE HISTORY

J. R., American Negro, aged fifty-two, was first seen by the author on March 1, 1939. He stated that he had fallen down a flight of stairs on June 25, 1938, during which fall he had twisted the right knee. It became painful and swollen, and he consulted a physician who treated him with physiotherapy for several months. He continued to work, but in the course of time the knee became continuously more painful and swollen.

Examination nine months after injury showed the patient in good general condition. He walked with a slight limp on the right side and did not completely extend the knee. In the recumbent position the angle of greatest flexion was 90 degrees, and the angle of greatest extension 170 degrees. The knee was distended with fluid and was one inch larger than the left. There was definite localized tenderness over the medial meniscus, and rotation of the leg inward upon the thigh caused severe pain, but external rotation produced no discomfort. A diagnosis of internal derangement was made, and meniscectomy was advised. Roentgenographic examination showed no pathology of any kind, other than the distention of the joint with fluid.

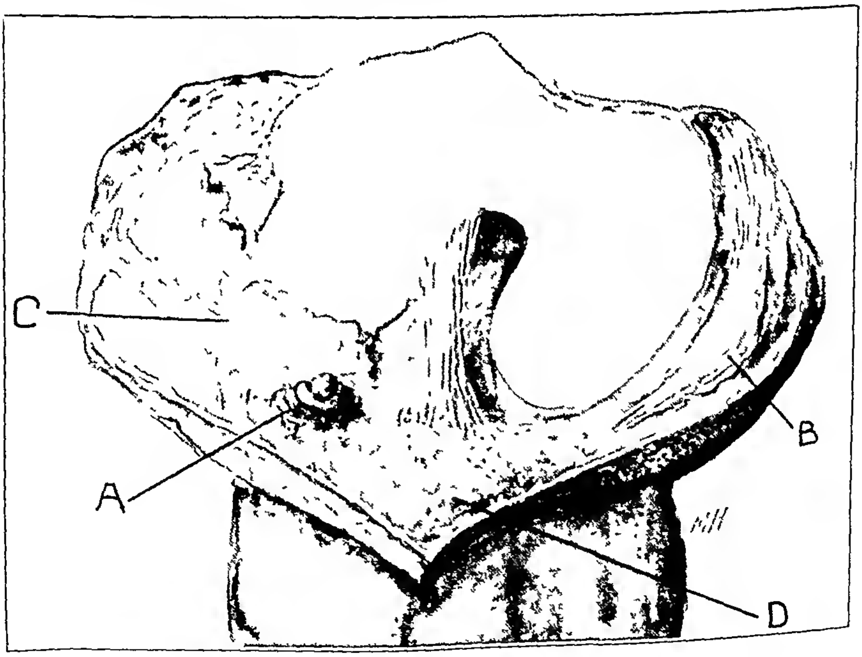

FIG. 1

View of interior of knee joint, showing the tumor.
A: Solitary tumor arising from synovial membrane. *B:* Retracted patella.
C: Hypertrophied synovial membrane. *D:* Enlarged fat pad.

Fig 2

Photomicrograph of section of tumor tissue. *A*. Giant cell *B* Fibrous stroma. *C* "Synovium-like" cells

A week after this examination, the distention of his knee was very much greater. The joint was aspirated and about 60 cubic centimeters of dark, oily, amber-colored fluid was removed. The knee was bandaged. The aspiration was repeated about a week later. The joint became distended again and the patient was admitted to the Hospital for Joint Diseases on March 27, 1939. Examination on admission showed the condition to be similar to that previously described, with the addition of distention posteriorly. Diagnosis of a possible Baker's cyst was made.

An arthrotomy was performed April 4, 1939, through a median parapatellar incision. On opening the joint, there was a gush of considerable synovial fluid. The medial meniscus showed a very small tear and was removed. Imbedded in the fat pad, but arising from the synovial membrane reflected over it, there was a yellowish tumor resembling a xanthoma. This was completely excised, the wound closed in the usual manner, and a compression bandage applied. The patient made an uneventful recovery and on April 19, 1939, was discharged, walking with the aid of crutches. He was treated postoperatively with physiotherapy, and on June 9, 1939, was able to return to work. Examination on that day showed that the right knee was moderately swollen. There was no fluid in the popliteal region, and motion of the knee was possible from 180 degrees of extension to 75 degrees of flexion. Measurements showed that the right knee was only half an inch larger than the left.

The pathological report of tissue removed, made by Henry L. Jaffe, M.D., was:

"*Gross Examination:* The specimen consisted of a lesion removed from the region of the ligamentum mucosum. Beneath the synovial lining, there was a rather firm, brownishly discolored, lobulated tumorous growth which measured roughly 2.5 by 2 by 1.5 centimeters. The material received also included a fragment of somewhat injected synovial membrane. Within the latter, a small whitish (in places yellowish) and discolored, discrete nodule, one centimeter in greatest diameter, was encountered. A meniscus was also received which showed nothing remarkable.

"*Microscopic Examination:* Sections showed well-circumscribed tumor nodules with nearby bits of synovial membrane and pieces from other points in the joint. The tumor nodules occupied the entire thickness of the synovial and subsynovial membrane. The tissue consisted of a fibrous stroma containing myriad 'synovium-like' cells and many giant cells. There was no evidence of lipoid-containing foam cells in the routine or spinal fat-stain sections. A small amount of hemosiderin was present. The neighboring synovial and subsynovial membrane was sharply demarcated from the tumor nodules, but showed some villous formation, hyperplasia, and hypertrophy of the synovial cells. There were several focal collections of lymphocytes. The whitish nodule was composed of highly collagenous fibrous tissue which had apparently undergone traumatic damage.

"*Diagnosis:* Giant-cell tumor of the synovial membrane of the knee joint."

Although this patient has been working since June 9, 1939, there has been a recurrence of pain and swelling of the right knee. To relieve this, physiotherapy was instituted and carried out for a number of months without much improvement.

Examination made in October 1939, revealed that the right knee was slightly swollen and contained a small quantity of fluid. Extension was restricted to about 175 degrees, and flexion to 90. The patient walked with a limp on the right side. Motion of the limb was accompanied by pain. He was referred to Dr. James Ewing who instituted deep roentgen-ray therapy. A full course of treatments consisting of 200 roentgen units to the front and 200 roentgen units to the back of the knee was given five times, the last one on January 3, 1940.

Following this treatment, the patient returned to work and when last examined, in August 1940, gave no evidence of recurrence of the tumor, although the knee showed limitation of about 10 degrees in extension and of about 15 degrees in flexion.

At the present time (October 1940), this patient is carrying on his usual occupation of elevator operator and porter.

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TUBERCULOSIS OF THE SHOULDER

A Report of Four Cases Treated by Operative Fusion

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Tuberculosis of the shoulder must be differentiated from chronic disabilities of the shoulder which are chiefly the degenerative, traumatic, and infectious arthritides, and the cases of long-standing periarticular calcification and bursitis.

The prognosis after treatment is generally good in uncomplicated cases, but poor when active pulmonary disease or local abscess is present.

The primary treatment is that of general supportive measures. Local treatment may be conservative or operative. Conservative treatment has for its aim the healing of the shoulder joint in an optimum position for function through the various methods of extrinsic splinting only. By this method fibrous ankylosis may occur in three to five years, but it is generally insecure, and the arm from its own weight gradually loses its desirable abducted position, and ultimately comes to rest in a poor functional position.

In the operative field, the procedure of choice in the uncomplicated cases is extra-articular fusion by means of an osteoperiosteal graft from the acromion to the neck of the humerus. Provided that postoperative splinting is proper and of sufficient duration, intra-articular healing and bony ankylosis almost inevitably occur. The arm should be slightly forward and abducted to 70 degrees. Solid fusion has generally taken place in four to eight months. The outcome following intra-articular fusion is unpredictable.

Briefly, the operative technique is as follows: The preoperative orthopaedic preparation is applied to the shoulder and to the opposite leg. Operation is done on the Hawley table. One or two osteoperiosteal grafts (depending upon the size of the patient), measuring one-half by three inches in size, are removed from the tibia and set aside in saline packs. The leg wound is closed. An anterior deltoid-splitting incision, extending over the acromion process, is made, the fibroperiosteum of the acromion and upper humerus is incised and stripped aside, the smooth cortical surface of the acromion and upper humerus is denuded with an osteotome, and the osseous surfaces of the graft are applied to this raw bed of bone. The joint is not entered. Fibroperiosteum is sutured over the grafts with chromic catgut and this holds them securely in place, for during the process the arm has been held in the desired position. The soft tissues are closed in the usual fashion, and the skin

Fig 1-A

Case 1. Roentgenogram taken September 16, 1936, shows irregularity of the head of the humerus with multiple areas of rarefaction in the greater tuberosity and in the glenoid cavity

Fig 1-B

Case 1. Six months after extra-articular fusion, roentgenogram shows solid bony union between humerus and acromion

is sutured with silk. A plaster shoulder spica is applied with the arm in about 70 degrees' abduction, slightly forward and in neutral rotation.

REPORT OF CASES

CASE 1. E. K., a white female, aged forty-eight, was first admitted to the hospital on September 16, 1936, with a history of vague, intermittent pain in the right shoulder joint for twenty-five years. There was occasional radiation to the finger tips. The pain suddenly became worse five months before admission, and marked limitation of motion had occurred. There was no history of trauma or tuberculosis contacts.

There was moderate generalized atrophy of the right shoulder joint and the arm was fixed in adduction. All attempted motions were painful. No inflammatory signs were present. Roentgenograms showed an irregularity of the head of the humerus and multiple areas of rarefaction in the humerus and the glenoid (Fig. 1-A). Laboratory studies were normal.

Exploration was carried out and the joint was found to be filled with soft, friable, whitish-gray granulation tissue. This same material had replaced part of the humeral head. Articular cartilage and necrotic bone of humerus and glenoid were removed and a plaster abduction spica was applied. Microscopic examination of the removed tissue revealed tuberculosis.

After six months of spica fixation, no fusion had occurred. On February 23, 1937, an extra-articular fusion with a tibial osteoperiosteal graft was done by Dr. Maxwell Harbin. An abduction spica was worn for six months when solid bony ankylosis had occurred (Fig. 1-B).

Since then she has had a stable painless shoulder and has had no restriction in the use of the arm (Fig. 1-C).

FIG. 1-C

Case 1. Double-exposure photograph shows range of abduction of right humerus, one year following extra-articular operation.

CASE 2. R. S., a white male, eleven years of age, entered the hospital on April 8, 1936, with the complaint of pain in the right shoulder of one month's duration. There was no history of trauma or other joint disease. His father had died from pulmonary tuberculosis.

There was moderate generalized atrophy of the right shoulder joint with fixed adduction to the chest wall. No passive motion was permitted. There was no local heat or tenderness present. Roentgenograms showed extensive destruction of the upper humerus, the capital epiphysis, and the glenoid (Fig. 2-A). A tuberculin test (1:1000 human) was strongly positive. The laboratory findings were normal.

Because of his age, conservative treatment in an abduction spica was carried out for six months, but fusion did not occur, and the abduction gradually decreased during the next five months. On March 6, 1937, an extra-articular fusion with a tibial osteoperiosteal graft was done by Dr. Maxwell Harbin, and an abduction spica was applied.

Microscopic examination of the removed granulation tissue revealed scar tissue, the seat of chronic inflammation, with no evidence of tuberculosis. Solid bony union

FIG. 2-A

Case 2. Roentgenogram taken April 8, 1936, shows marked destruction of the capital epiphysis and of the glenoid cavity. There is a large cystic area in the proximal diaphysis of the humerus.

FIG. 2-B

Case 2. Postoperative roentgenogram shows complete intra-articular and extra-articular bony union four and one-half months after operation.

occurred in four months (Fig. 2-B). He has a painless stable shoulder with no limitation of use (Fig. 2-C).

Case 3. G. P., a white male, eleven years of age, was admitted to the hospital in November 1936, for an arthrodesis of a tuberculous left hip. For two weeks prior to admission he had complained of pain in the right shoulder without any history of trauma.

Slight atrophy of the right shoulder joint was present, and abduction beyond 45 degrees was painful. Roentgenograms revealed an extensive destructive process involving the head of the humerus and the glenoid (Fig. 3-B). Laboratory findings were normal.

During his convalescence from the hip arthrodesis, the shoulder was treated conservatively. On July 22, 1937, Dr. Maxwell Harbin performed an extra-articular fusion of the shoulder joint with a tibial osteoperiosteal graft. Microscopic examination of the granulation tissue revealed tuberculosis. Solid bony ankylosis occurred after four months of abduction splinting (Fig. 3-C).

At present, the right shoulder and left hip are painless and stable, and the patient enjoys normal activities (Fig. 3-A).

Case 4. R. N., a white male, eight years of age, was admitted to the hospital in November 1936, because of a painful right shoulder of ten months' duration. From September 1931 to October 1934 he was treated in another city for dorsal Pott's disease. He made an excellent recovery from a spine fusion and was well until pain in the shoulder occurred.

There was marked diffuse atrophy and muscle spasm of the right shoulder joint. All motion was painful. There was tenderness to pressure over the anterior joint space. He had marked lower dorsal kyphosis. Roentgenograms, taken on admission

Fig. 2-C

Case 2. Double-exposure photograph taken six months after operation shows excellent range of abduction.

Fig. 3-A

Case 3. Double-exposure photograph, taken six months after operation, shows excellent range of abduction.

and others taken nine months later, revealed an extensive destruction of the humeral head and the glenoid (Fig. 4-A). Sedimentation rate was accelerated.

For one year he was treated conservatively in plaster abduction spicas, but fusion did

FIG. 3-B

Case 3. Preoperative roentgenogram of the right shoulder taken November 27, 1936, shows marked destruction of the head of the humerus and the glenoid cavity.

FIG. 3-C

Case 3. Roentgenogram, taken December 14, 1937, four and three-quarters months after extra-articular fusion, shows good bony union.

Fig. 4-A

Case 4. Preoperative roentgenogram of the right shoulder, taken August 21, 1937, after nine months of conservative treatment, shows an extensive destruction of the epiphysis of the humerus and of the glenoid cavity.

Fig. 4-B

Case 4. Roentgenogram, taken April 16, 1938, five months after operation, shows solid bony fusion between the humerus and scapula.

Fig. 4-C

Case 4. Double-exposure photograph taken six months after operation shows range of abduction.

not occur. An extra-articular fusion with a tibial osteoperiosteal graft was done on November 13, 1937, and bony ankylosis was complete in five months (Fig. 4-B). Microscopic examination of the removed granulation tissue had confirmed the diagnosis of tuberculosis. He has a painless stable shoulder with excellent range of motion (Fig. 4-C).

SUMMARY

Four cases of tuberculosis of the shoulder which were treated by extra-articular arthrodesis are presented. Three cases occurred in male children, and the fourth in an adult female. All involved the right shoulder joint. No history of local trauma was elicited in any case. The shortest duration of symptoms before diagnosis was made was two weeks and the longest duration was twenty-five years. Extra-articular fusion was done on these four patients, and bony ankylosis was demonstrated clinically and roentgenologically four to six months after operation. Ankylosis occurred in six months in the adult female, in whom a previous intra-articular fusion had met with failure. The juvenile patients showed solid ankylosis in four to five months after operation, whereas conservative treatment for periods of six, eight, and twelve months, respectively, had failed to produce fusion.

The authors believe that extra-articular arthrodesis of the tubercu-

lous shoulder joint should be carried out as soon as the diagnosis is established, provided that none of the more serious local or systemic complications are present. Intra-articular arthrodesis is unreliable, as evidenced by the failure of fusion in our adult patient, and conservative treatment furnishes no guarantee of healing, unless perhaps fixation be carried out for an interminable period. The shoulder joints of the four patients are healed and are functionally excellent.

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IRREDUCIBLE LATERAL DISLOCATION OF THE PATELLA WITH ROTATION

A Case Report

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Robert Liston is credited with the remark that, "he never had the fortune to perform the good office of reducing a patella for a patient". The inference, of course, is that the dislocated patella usually reduces itself before the arrival of the surgeon. While most dislocations of the patella are readily reduced, there have been reported, from time to time, cases of luxated patellae which have defied all attempts at closed reduction. Usually these dislocations have been complicated by fractures, luxations of the tibia, or rotary displacements of the patella. The case reported in this communication is of interest in that the lateral dislocation was associated with a complete rotation of the patella about its longitudinal axis.

CASE REPORT

T.P., an electrician, aged forty-three, was brought to the Emergency Hospital in the afternoon of February 3, 1940. He had parked his automobile in the driveway about ten feet from the garage doors. The driveway sloped rather steeply downward into the garage. After setting the hand brake and alighting from the car, he proceeded to unlock the garage doors. The brakes loosened and the automobile rolled down upon him. He attempted to avoid being crushed between the oncoming car and the door by jumping in the air and grasping the radiator cap with his hands. His left knee was caught between the fender of the car and the closed door. The impact was sufficient to tear the door from its hinges and carried him, still clinging to the radiator cap, into the interior of the garage.

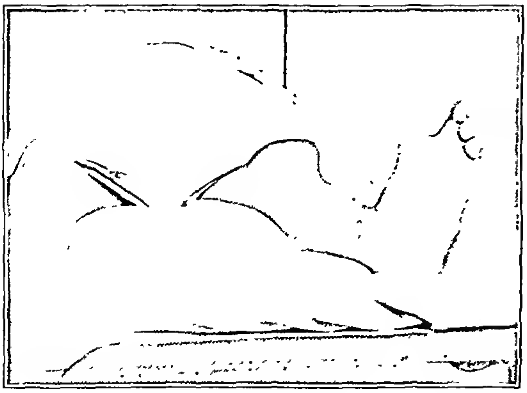

Fig. 1

Appearance of left knee prior to reduction.

Examination of the patient on arrival at the Emergency Hospital disclosed slight swelling of the left knee. There were abrasions over both the inner and outer aspects of the knee. The patella could be easily palpated, lying in the sagittal plane over the outer edge of the lateral femoral condyle, and the diagnosis of a lateral dislocation of the patella was obvious (Fig. 1). Roentgenograms were secured which substantiated the clinical findings and in addition revealed an insignificant fracture of the lateral femoral condyle.

An attempt was made to reduce the patella without anaesthesia. Pressure was exerted with both thumbs on its posterior edge, but the patella remained immovable. Ether anaesthesia was administered and after complete relaxation, reduction was again attempted. In spite of full flexion of the hip and extension of the knee, every trial proved ineffectual. Finally after preparation of the skin, a bone hook was inserted around the posterior edge of the patella, to which forceful traction was applied, in an endeavor to slide the patella over the prominence of the lateral femoral condyle. This procedure, like the previous ones, ended in failure.

The following day the patient was returned to the operating room, given a spinal anaesthetic, and again attempts were made to slide the patella back over the lateral femoral condyle. The knee was flexed forcibly about twenty degrees to loosen the locked patella. The hip was sharply flexed on the abdomen to relax the quadriceps, and the knee was fully extended. These attempts again failed to achieve reduction.

Suspecting that rotation of the patella was the cause of our inability to secure reduction, a series of tangential roentgenograms were taken. In one of these views, a true lateral projection of the patella was obtained, which revealed the correct status. The articular surface was found to be directed outward and the non-articular surface faced the femoral condyle. The patella had rotated during its lateral displacement somewhat more than ninety degrees (Figs. 2-A and 2-B).

The skin lacerations about the knee prevented immediate open reduction of the patella. Two weeks elapsed before the skin was sufficiently healed to permit surgical intervention and at the expiration of this time, under general anaesthesia, the knee was opened through a medial parapatellar incision. The distal portion of the quadriceps tendon and the proximal portion of the patellar tendon were exposed, and the early fibroblastic scar tissue was dissected away. The medial attachments of the patella were completely torn; and the patella was avulsed subperiosteally from the vastus medialis, the medial two-thirds of the quadriceps, and the medial half of the patellar tendon. All lateral attachments were intact and the patella had rotated internally about these attachments through approximately 110 degrees, so that its articular surface faced outward (Fig. 3).

FIG. 2-A

FIG. 2-B

Oblique roentgenograms of the left knee (reversed in reproductions). Note the position of the patella lying lateral to the femoral condyle, with the articular surface facing outward. The small fracture of the lateral femoral condyle is visible in Fig. 2-A.

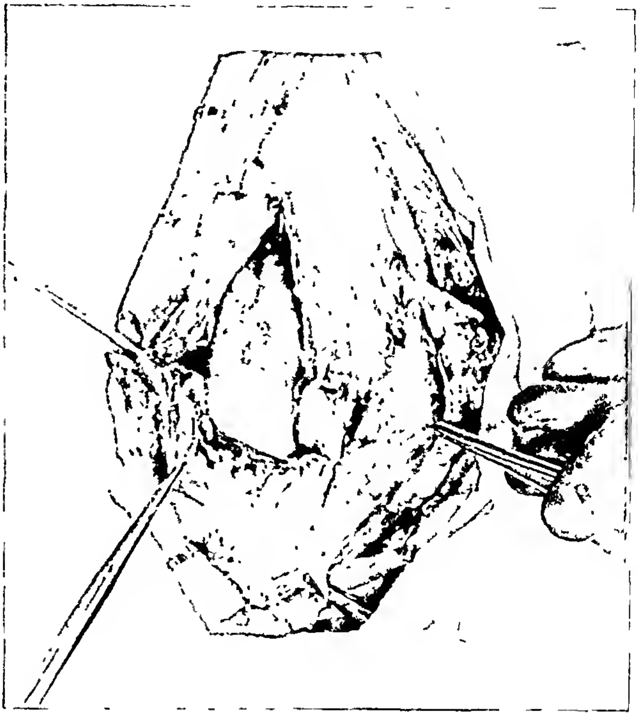

FIG. 3

Photograph of the surgical exposure of the knee. Note the patella lying at the side of the lateral femoral condyle, with its non-articular surface in contact with the femur. The torn medial fibers of the patellar ligament and the quadriceps tendon are apparent.

The patella was readily reduced by retracting its anterior edge laterally and inserting a periosteal elevator between the lateral femoral condyle and the patella. Using a periosteal elevator as a skid, the posterior edge of the patella was slipped upward and over the condyle; the patella was derotated spontaneously and fell into position with its articular surface in contact with the patellar surface of the femur.

The surgical repair of the torn structures consisted of suturing the rent between the vastus medialis and quadriceps tendon. The distal fibers of the vastus medialis were affixed to the medial side of the patella with two mattress sutures of braided silk passed through holes drilled obliquely into the edge of the patella. The fascial expansion over the patella, the subcutaneous tissue, and skin were closed in layers with interrupted, black silk sutures. The knee was immobilized in a plaster cast with the knee in approximately fifteen degrees of flexion.

The wound healed rapidly and the cast was removed on the twelfth postoperative day. Passive motion and quadriceps setting exercises were started. The patient was discharged on the seventeenth postoperative day, using crutches and refraining from weight-bearing upon the left leg. At the time of discharge, there was active extension of the knee to 165 degrees and flexion to 135 degrees. There was no pain or crepitus on motion and no tendency for the patella to luxate laterally.

Soon after discharge from the hospital, the patient, on his own volition, discarded his crutches. One month later, patient had a range of active motion through 50 degrees, with a 15-degree flexion contracture.

Eight months after the open reduction, the patient had no pain, no swelling, and no tenderness. The patella was only slightly movable from side to side. Extension of the left knee was possible to 175 degrees and flexion to 65 degrees. There was no obvious atrophy of the thigh or leg and no demonstrable muscle weakness (Fig. 4).

DISCUSSION

A search through the literature has uncovered few similar cases of lateral dislocation of the patella complicated by rotation about its longitudinal axis. Cooper appears to have recorded the earliest case in 1844. From his description it is difficult to be certain to what extent the patella had rotated during its lateral displacement, but it was sufficient to permit

the patella to come to rest "with its inner edge upon the outer surface of the external condyle, the fore part of the patella facing forwards and inwards. As the patient lay with the knee extended he experienced no pain; there was no tension of the quadriceps extensor cruris; the patella admitted of a slight degree of motion forward or backward, turning upon its inner edge, which seemed caught behind the prominent margin of the articular surface of the condyle." All attempts at reduction were unavailing, until with considerable force the knee was sharply flexed to a point where the heel contacted the thigh. At the termination of this manoeuvre, the patella spontaneously reduced itself.

In 1856, Sanborn reported a similar case in a twenty-year-old man, in which all manipulation was ineffectual until the patient was anaesthetized and the leg was flexed forcibly on the thigh. By this process the patella was lifted from its unnatural position and the reduction was instantaneous. It was not until 1901 that Borchard reported another case of rotary and lateral dislocation of the patella. The injury occurred in a seventeen-year-old boy, who stumbled and fell while in the act of throwing a snowball. Examination of the knee eight hours after the accident disclosed the patella firmly lodged over the lateral femoral condyle. Both the ligamentum patellae and the tendon of the quadriceps femoris could be palpated, but were lax rather than taut. Reduction was accomplished with great difficulty, under anaesthesia, by derotating the patella with the thumb and forefinger. The laxness of the patellar tendon and the tendon of the quadriceps femoris, the author felt, indicated it was the rotation of the patella which locked it over the femoral condyle rather than any tight ligamentous structures. The following year

Fig. 4-A

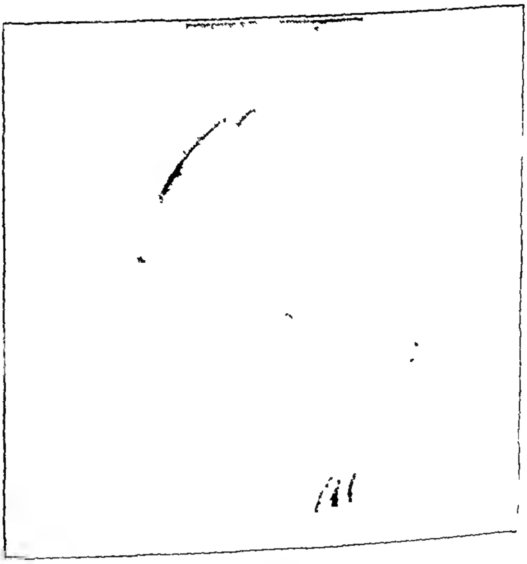

Fig. 4-B

Appearance of left knee eight months following open reduction. The photographs indicate the range and limits of active motion.

Hotchkiss reported a similar case in a twenty-year-old rigger whose leg became entangled in a rope down which he was sliding. The greatest difficulty, even under deep anaesthesia, was encountered in accomplishing a reduction. The method finally proving successful consisted of sudden forceful overextension of the knee, together with pressure exerted by both thumbs below the edge of the patella, forcing its posterior border over the femoral condyle.

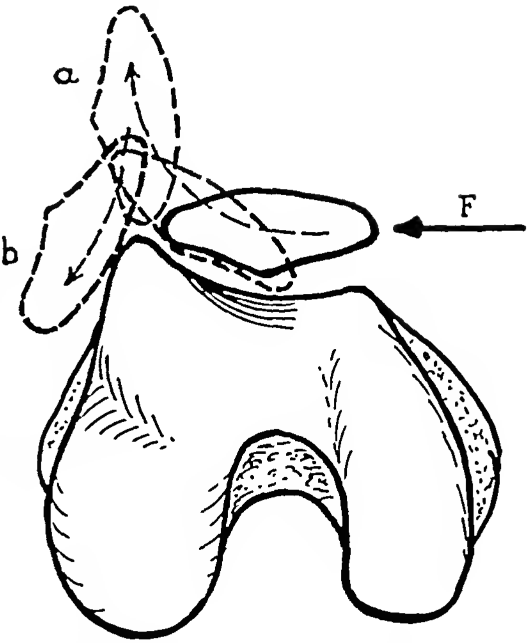

Fig. 5

Sketch showing the path the patella must take in its lateral dislocation with rotation about the long axis. *F:* The direction of the dislocating force; *a:* the position of the patella resulting from its sliding up on the lateral condyle; *b:* the position of the patella, where it becomes locked, after the medial edge clears the condyle.

During the past two decades there have been three additional cases reported by Trausner, Orsós, and Martin. In the case recorded by Trausner, there was a concomitant lateral luxation of the tibia which carried the patella with it. In all these cases, with the exception of the one reported by Orsós, reduction of the patella required surgical intervention; all closed methods proved of no avail. In each case it was found that the patella had rotated so that its medial edge became locked over the border of the lateral femoral condyle, with the articular surface facing outward. After arthrotomy, the dislocations were readily reduced by simply elevating the edge of the patella over the femoral condyle, following which the patella tended to derotate spontaneously and reduce itself. Surprisingly, Martin states that there was no appreciable tearing of the capsular structures demonstrable at operation, in spite of the marked displacement of the patella. This is at variance with the operative findings in the authors' case.

From a review of the cases reported in the literature, and from a study of the authors' own case, it is apparent that such lateral dislocation of the patella, with a rotation about its longitudinal axis, must result from a blow directly upon the medial side of the patella while the quadriceps femoris is taut. It appears to be essential that the knee be in almost complete extension at the time the forces act. This fact suggests the explanation for the rotation of the patella. During the final 20 to 25 degrees of extension of the knee, the patella rides against the lateral femoral condyle, which is bulwarked to resist the normal tendency of the patella to slide laterally. When the dislocating force carries the patella laterally, its

outer edge must ride upon the raised lateral femoral condyle. This produces a torque, tending to rotate the patella about a longitudinal axis. If the primary force is sufficiently great and acts through an adequate period of time, the patella is not only rotated, but carried beyond the lateral femoral condyle over which the medial edge of the patella becomes locked (Fig. 5).

It would seem that a dislocation of this nature would be impossible unless the attachments of the vastus medialis to the patella were avulsed at the same time. Although manual reduction is perhaps possible, once the nature of the rotation has been detected, the authors feel that open reduction is probably the method of choice in order to repair these important attachments, and so restore the full strength of the limb, and prevent any further tendency to lateral dislocation.

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TESTICULAR TERATOMA METASTASIZING TO THE SPINE

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It is generally believed that more than 96 per cent. of testicular tumors are malignant.[1]

Metastasis occurs by way of the lymphatic and venous systems. When by the lymphatic route, extension is up the lymphatics of the spermatic cord to the pelvic, lumbar, and epigastric nodes, thence to the prevertebral chain, through the mediastinum and along the thoracic duct to the left supraclavicular fossa. When by the venous system, metastasis is first pulmonary in nature. By either route the metastasis is rapid.[1]

A laboratory aid in diagnosis and prognosis is to be found in the determination of the presence of prolan A in the urine. This test has now been refined and is used not alone in the diagnosis, but as a guide to the progress of the patient, and the response of the tumor to radiation. The persistence of a strongly positive prolan test after orchectomy is considered evidence of subclinical metastasis when other examination for this is negative.

There are surprisingly few reports in the literature pertaining to teratoma of the testicle metastasizing to bone. Geschickter states that only one instance (to the frontal bone) occurred in forty-two cases registered at the Johns Hopkins Surgical Pathological Laboratory. Eisendrath has reported a case of a malignant mixed tumor of an undescended testicle, which metastasized to the femoral head, and was discovered through bone destruction a year after removal of the primary tumor. Reports of metastasis to or about the spine are rare. Bricka and Pons report a case of a male twenty-seven years old, whose left testicle had been removed. One year later a large mass was present in the left side of the abdomen and flank. At autopsy this tumor was found to have been teratomatous. Kennedy and Stevenson report a case of teratoma of the left testis, which metastasized to the anterolateral aspect of the vertebral column in the lower dorsal area, invaded the tenth dorsal body, and produced necrosis of the cord distal to this level.

The following case of testicular teratoma, metastasizing to the spine with resulting paraplegia and sensory loss below the level of the involvement of the spinal cord, is reported as unusual. The authors feel it should be of interest to orthopaedic surgeons who find themselves confronted by the same situation, and may warn them that they are dealing, not with a simple compression fracture, but rather with a pathological one.

CASE REPORT

R. C., twenty-four years of age, a white male, was seen on February 12, 1940, with a complaint of pain in the lumbar and lower thoracic regions of the back. The onset of

his complaints followed a fall on January 17, 1940. The patient had been carrying a heavy automobile battery and had fallen a short distance, striking the buttocks. For about one month he had been receiving ambulatory treatment without benefit, and the back pain had increased in severity. Roentgenograms on February 12 (Fig. 1) revealed the presence of a compression fracture of moderate degree, involving the eleventh thoracic vertebra. Compression was of the wedge type with no posterior protrusion. Anteroposterior projections showed no lateral wedging and there was no evidence of fracture of the laminae or pedicles. Clinical examination revealed bilateral muscle spasm at the level of the thoracolumbar junction and localized tenderness over the eleventh thoracic spinous process. At this time there were no symptoms referable to the central nervous system, nor were there any objective neurological findings.

The right testicle was considerably enlarged. This was said to have been present for six years, following trauma to that testicle in a football game. The patient asserted that the mass had not increased in size, had never been productive of pain, nor caused discomfort of any nature. On examination the mass measured fifteen by ten by ten centimeters, was not nodular, was of a uniformly firm consistency, and was not tender. It did not transilluminate and there was no enlargement of the regional lymph nodes

He was referred to the hospital where on the following day under general anaesthesia reduction of the compression fracture by hyperextension was done. A check roentgenogram revealed the compression had been entirely corrected (Fig. 2). A plaster jacket extending from the sternal notch to the symphysis ossium pubis was applied in the usual

FIG. 1

Compression fracture of the eleventh thoracic vertebra before manipulation.

FIG. 2

Compression fracture of the eleventh thoracic vertebra after reduction.

manner, the patient resting prone on the swathe. On recovering consciousness, the patient complained of numbness of his legs and inability to move them. The plaster jacket was immediately removed. On neurological examination it was found that there was complete flaccid paralysis of the lower extremities and the abdominal muscles, and loss of function of the rectum and bladder. There was complete loss of superficial sensation below the level of the twelfth thoracic dermatome anteriorly and posteriorly. Deepsensibility was absent in the lower extremities up to, and including, the iliac crests.

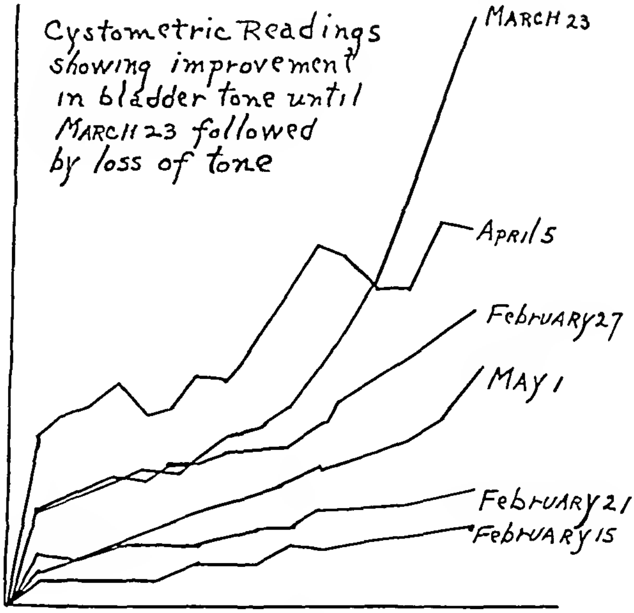

Fig. 3

Cystometric readings, showing improvement in bladder tone until March 23, followed by loss of tone.

A lumbar puncture was not done for several days because of the extreme tenderness of the back. At this time, roentgenograms were again taken and failed to show any evidence of dislocation. The neurosurgical consultant advised against surgery because of the lack of bony encroachment on the spinal canal. A cystometrogram showed that the bladder was atonic and tidal drainage was instituted. On February 21, a lumbar puncture revealed xanthochromic fluid with an initial pressure of 21 millimeters of water, prompt rise and fall with abdominal pressure, but no rise with jugular compression. There were no cells in the fluid; the Wassermann was negative; and the total protein was 95 milligrams per cent. Air myelography revealed a complete block at the lower border of the tenth thoracic vertebra. Because of the lack of clinical improvement a laminectomy from the ninth thoracic to the twelfth thoracic vertebrae inclusive was performed on February 23. The spinal cord was found markedly swollen opposite the tenth and eleventh thoracic spinous processes. There was no evidence of tumor, fracture of bony structures, or posteriorly protruding intervetebral disc. Following operation some sensory return occurred,—spotty and indefinite in nature. Motor function failed to return at any time. Bladder function improved as evidenced by weekly cystometrogram determinations (Fig. 3). However, after several weeks the bladder returned to its atonic state, probably on account of a complicating low-grade urinary infection. In spite of careful nursing, the usual decubitus ulcers over the sacrum and greater trochanters occurred. Ten weeks following operation, the patient developed evidence of nerve-root irritation, evidenced by hypersensitivity from the region of the left shoulder to the upper abdomen. On repeated lumbar punctures the spinal block continued, along with an increase in the total protein content of the spinal fluid. A short time later a mass was noticed to the left of the seventh thoracic spinous process. A roentgenogram (Fig. 4) taken at this time, June 4, indicated a sharply defined, homogeneous, soft-tissue shadow, extending from the seventh to the twelfth thoracic vertebrae, and varying from six to ten centimeters in width. A lateral view indicated that compression of the eleventh thoracic vertebral body had recurred and progressed (Fig. 5). Aspiration of the mass was done and a few drops of mucoid material was obtained. This was reported to be myxoma. The existence of a neoplasm at and about

Fig. 4

Anteroposterior roentgenogram showing soft-tissue shadow of tumor three and one-half months following paralysis.

Fig. 5

Compression fracture of the eleventh thoracic vertebra, showing recurrence of compression after removal of hyper-extension jacket.

the fracture site, secondary to the testicular mass, was considered probable. An Aschheim-Zondek test was done, but on account of the infected urine the animal died. In view of the continuation of severe root pain uncontrolled by opiates, a chordotomy in the upper thoracic region was performed as a palliative measure on July 3. At this operation no effort was made to re-explore the lower thoracic laminectomy, and no evidence of neoplasm or other abnormality was found at the time of the second operation. After several days the root pains were relieved. Subsequent to this operation, the patient developed bronchopneumonia and died July 21, 1940.

AUTOPSY RECORD

Right Scrotum. The right testicle was markedly enlarged. On section (Fig. 6) a tumor was found which was apparently composed of many different kinds of tissue (Figs. 7 and 8). A portion of the mass contained what appeared to be cartilage; the remainder of the specimen presented a large amount of necrosis. The tumor mass extended upward to involve the spermatic cord.

Back. The scars of two laminectomies were present (upper and lower thoracic regions). There was a small sinus opening in the skin at the level of the fifth thoracic vertebra. Beneath the site of the lower laminectomy was a firm grayish-white tumor mass which apparently infiltrated the musculature of the back. It extended from the eighth thoracic to the region of the first and second lumbar vertebrae. It extended

FIG. 6

Gross specimen of testicle and lumbar muscles.

Fig. 7

Photomicrograph of testicular tumor, showing variation in epithelial structure. (× 280.)

Fig. 8

Photomicrograph of testicular tumor, showing epithelial structure with myxomatous and sarcomatous stroma. (× 115.)

Fig. 9

Photomicrograph of metastasis in spinal cord. (× 63.)

Fig. 10

Photomicrograph of metastasis in bone. (× 125.)

about seven centimeters to the left of the mid-line, and almost the same distance to the right. The tumor extended completely around the cord (Fig. 9) at the level of the eleventh thoracic vertebra, the body of which had been partially destroyed (Fig. 10). The spinal cord between the levels of the fourth and fifth cervical vertebrae contained some sutures (site of chordotomy). The area surrounding the cord at this point was dark red and soft. Some red fluid was present.

Microscopic Diagnosis. Teratoma (embryoma) of right testicle with metastasis to vertebrae of the upper lumbar, and lower and mid-thoracic regions.

CONCLUSIONS

From a review of the literature, it was found that teratomata with this type of metastasis—teratoma of the right testicle with metastasis to the vertebrae, paravertebral structures, and spinal cord—are rare. The unusual features in this case are as follows:

1. The length of time the mass in the testicle had been known to have existed (six years).
2. Trauma sufficient to cause a compression fracture of the spine preceded the onset of symptoms.
3. Absence of evidence of invasion of the central or peripheral nervous systems up to the time the compression fracture was reduced.
4. Absence of evidence of involvement of bone or the spinal cord at the time of the first laminectomy.
5. Lack of roentgenographic evidence of the true pathological nature of the involved vertebrae at the first examination.

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INTERCONDYLAR T FRACTURE OF ELBOW

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For the treatment of intercondylar or T fracture of the elbow, Miller has suggested nailing the fragments and Reich has advocated traction, both of which methods undoubtedly will produce excellent results in many cases. Manipulation and closed reduction are always the method of choice, provided reduction can be obtained by this means.

This report presents a case of a T-shaped fracture of the elbow treated by closed reduction. The case is interesting, because the roentgenograms were misinterpreted by a number of competent roentgenologists. A careful study of the films, however, showed the correct relationship of the fragments, and closed manipulation, together with lateral compression of the elbow by means of a carpenter's clamp, resulted in a good alignment and a useful elbow.

CASE REPORT

The patient was a young girl of sixteen, who sustained a severe injury of the right elbow as a result of a fall from a bicycle. Roentgenograms (Figs. 1-A and 1-B) showed an intercondylar, T-shaped fracture of the lower end of the humerus, with rotation and displacement of the inner portion of the lower fragment, and some ulnar displacement of the outer portion. The first interpretation considered the lower articular surface to be lines *F E* and *D G*. The actual fracture surfaces are *A B* and *C D* and the margin of the lower articular surface of the trochlea and radial head are *E B* and *D G*. The surface *E F* is the margin of the internal condyle.

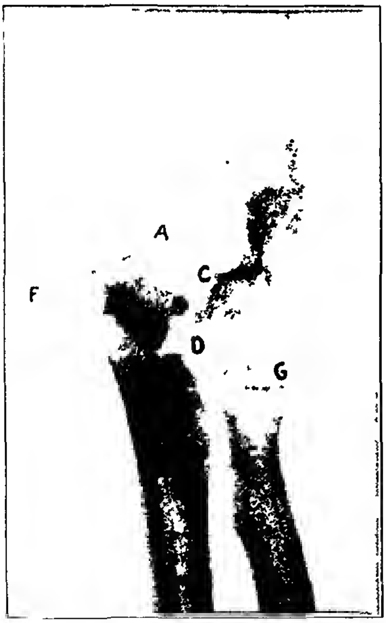

FIG. 1-A

FIG. 1-B

Intercondylar T-shaped fracture of the lower end of the humerus, with rotation of the inner fragment, and ulnar displacement of the outer fragment.

FIG. 2-A

FIG. 2-B

After manipulation the alignment is restored, but the inner fragment is displaced medially, and the metaphyseal portion is separated from the shaft of the humerus.

Under local anaesthesia an attempt was made to rotate the inner fragment by manipulation and thus approximate surfaces *A B* and *C D*, and place the elbow in acute flexion. Check-up roentgenograms showed an apparent normal relationship, but a definite separation of the two fragments; an oblique view (Fig. 2-B) showed that the metaphyseal portion of the lower fragment was separated quite a distance from the shaft, and the problem arose as to what was the best method of approximating the fragments. (In a somewhat similar situation, Dr. Wolfert used a carpenter's clamp in a case presented by him at a clinical meeting at the Hospital for Joint Diseases, and an excellent result was obtained.) A carpenter's clamp as seen in Figure 3 was then applied, over felt pads, to the lateral margin of the elbow joint, and fixed by means of a flannel bandage suspended from the neck. By grad-

FIG. 3

Carpenter's clamp is applied over the condyles of the humerus.

FIG. 4-A FIG. 4-B

Five months after institution of treatment, showing satisfactory alignment at the lower end of the humerus.

ually tightening the clamp, the fragments were slowly approximated. The patient was instructed to tighten the clamp daily to the amount of compression which she could endure without too much discomfort. No nerve injury resulted from the compression.

Roentgenograms were taken with the clamp *in situ* after lateral compression had been employed for several days. The opposing fractured surfaces were then in almost complete apposition, and the rotation had been almost completely corrected. The clamp was maintained for four weeks.

After removal of the clamp, physiotherapy was instituted, with the elbow gradually flexed and extended, until, after three months of active treatment, extension was possible to 170 degrees and flexion to 45 degrees, the tips of the fingers just reaching the shoulder. Roentgenograms (Figs. 4-A and 4-B), taken five months after the injury, showed good alignment of the fragments.

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A SPLINT TO INCREASE HIP AND KNEE MOTION

BY WILLIAM J. TOBIN, M.D., LIEUTENANT, MEDICAL CORPS RESERVE,
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From the Orthopaedic Service, Walter Reed General Hospital, Washington, D. C.

The splint described is a modification of the half-ring leg splint. The main feature of the modified splint is the maximum degree of hip and knee motion that is possible with its use. The splint was first used in connection with the postoperative treatment of patients upon whom vitallium-cup arthroplasty had been done, and in whom as much hip motion as possible was desired. It is also of value in knee cases, since any method that increases hip flexion obviously increases knee flexion.

The splint is simple in construction (Figs. 1 and 2). It may be used on either the right or left side by making the proximal and distal half rings hinged. The standard Pearson attachment or one of its modifications can be used to complete the splint. The patient's hip and knee are first exercised passively, and then, as muscle tone increases, actively (Fig. 3).

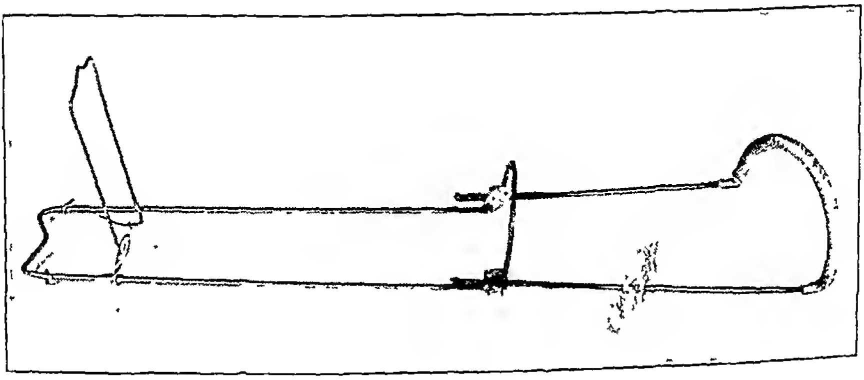

FIG. 1

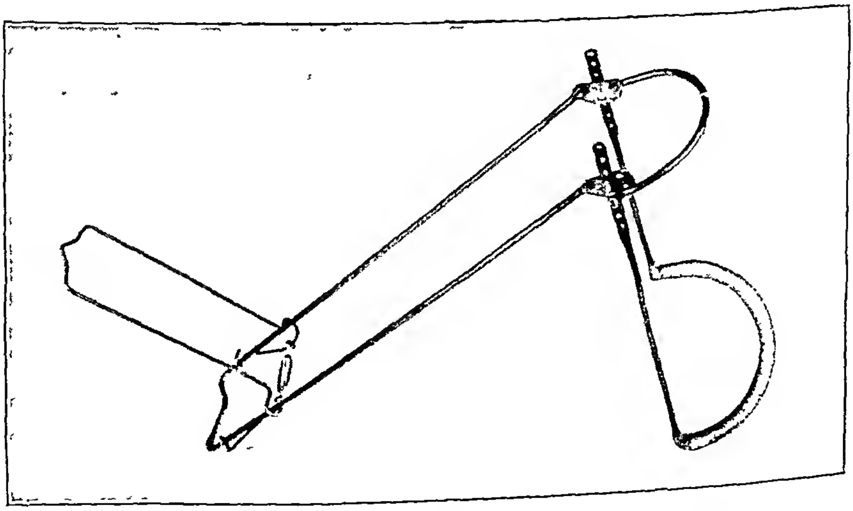

FIG. 2

FIG. 3

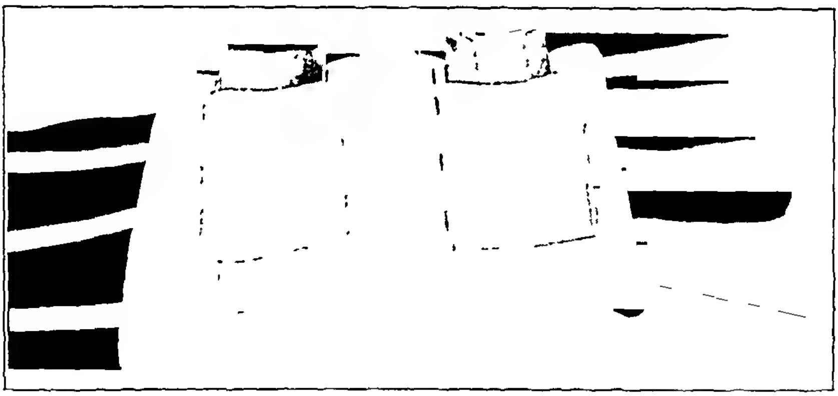

FIG. 4

The stiffening of the knee and hip joint that often exists after prolonged immobilization in a plaster east, requires many weeks of additional treatment before a good range of motion is regained. Often it is desirable to have some form of additional external support for the femur, as in the case of fraetures of the femoral shaft. A eanvas support with aluminum coaptation splints around the thigh might be used. Figure 4 shows the canvas support for the right thigh. This modified splint ean be used for any eondition about the hip and knee, in which early and full range of motion is the desired goal.

The author wishes to acknowledge the contribution by Dr. Carter R. Rowe in the original modification and early use of the splint.

AURELIUS RIVES SHANDS

1860–1941

Aurelius Rives Shands was born on November 5, 1860, in Prince George County, Virginia. He received his education in the South, where he attended McCabe's University School in Petersburg, Virginia, and later, the University Medical College (now the University of Maryland) in Baltimore.

After graduating in medicine in 1884, Dr. Shands established himself in Charles City County, Virginia, and engaged in general practice until 1892. He had become interested in orthopaedic surgery, which at that time was a limited but rapidly developing specialty in medicine and had but very few representatives in the South. He decided to train himself for this work and accordingly went to the Hospital for the Ruptured and Crippled in New York, serving first as a substitute intern and then as a regular intern during the year 1893, under the direction of Dr. Virgil P. Gibney. After completing his service there, he moved to Washington, D. C., where he started his practice of ortho-

paedic surgery and took an active and important part in placing this specialty in a recognized position in that city and in that part of the country.

The esteem in which Dr Shands was regarded by his associates is indicated by the many positions of public service which he held. He was Professor of Orthopaedic Surgery at George Washington University, and later was made Clinical Professor in that same University He was also Professor of Orthopaedic Surgery at the University of Vermont from 1900 to 1911. He was one of the founders of the New Emergency Hospital in Washington, of which he was Chief of the Orthopaedic Service, and Secretary of the staff for many years

He was a member of the Virginia State Medical Society, and he held the position of Vice-President of the District of Columbia Medical Society in 1902 He was Chairman of the Committee of Arrangements in Washington of the Congress of Physicians and Surgeons from 1900 to 1933, and he served as President of the Alumni Association of the Hospital for the Ruptured and Crippled in 1918 He was a Founder Member of the American College of Surgeons He was also an Emeritus Member of the American Academy of Orthopaedic Surgeons

Dr. Shands was elected a member of the American Orthopaedic Association in 1896 and served as its President in the year 1912-1913 He always participated in the affairs of the Association, both in the presentation and discussion of papers and in the administrative deliberations Members always looked forward to meeting him

He was influential in establishing orthopaedic surgery in its recognized position in the South, and always took an active part in this specialty until about three years ago when he retired to his farm in Virginia, which he had made his hobby and in which he was always interested He died in Washington, April 27, 1941

He was never a prolific writer, but contributed largely to some of the more important subjects which in that period needed development by the guidance of men of judgment and experience Among the subjects on which he wrote were Pott's disease, club-foot, hip-joint fractures, et cetera, and his experience added value to all of his literary contributions

Dr Shands was a man of strong convictions, but was never intrusive He had much of the courtesy of former generations and gave to those with whom he came in contact the feeling of the dignity of the "old school", with the hospitality of the South He was a pioneer in his specialty in Washington and in the South, and in a quiet way represented the best in orthopaedic surgery in his section of the country

His loss is realized by those who knew him in the period of his active service, and he was one of the members of the Association who will be greatly missed

WILLIS COHOON CAMPBELL

1880–1941

In the death of Willis Cohoon Campbell, May 4, 1941, in Chicago, orthopaedic surgery has lost one of its most active members and greatest leaders. He was born in Jackson, Mississippi, on December 18, 1880. He is survived by his wife, the former Elizabeth Yerger, whom he married in 1908.

His early education was received in his native state; his college and premedical training were taken at Hampden-Sydney College, Roanoke College; and his medical work, at the University of Virginia where he was graduated in 1904. After two years of internship, he entered the practice of medicine in Memphis. He early became interested in orthopaedic surgery, and, surmounting many hardships, he went to Europe to undertake the study of the specialty. He studied in London and Vienna, and had further postgraduate study in New York and Boston with the celebrated orthopaedic surgeons in this country at that time. He returned to Memphis in 1909 and resumed his practice, specializing in orthopaedic surgery.

In 1910 he was asked to organize a Department of Orthopaedic Surgery at the University of Tennessee Medical School and he became the first Professor of Orthopaedic Surgery in this institution, which office he held with distinction until his death. His

work in teaching was characterized by his desire to improve the teaching of orthopaedic surgery and postgraduate training.

Dr. Campbell realized the need for properly organized and conducted institutions for the care of indigent cripples, and he was one of the first to establish a crippled children's hospital school in that part of the South. After the establishment of the Crippled Children's Hospital School, he devoted his energy to the formation of a similar type of institution to continue the work for crippled children after they had passed childhood. He cherished the hope that some day he would see the foundation of an institution for the care of adult orthopaedic patients. With the cooperation of some of his close friends, this hope was realized in 1923 with the establishment of the Hospital for Crippled Adults.

In 1920 he built and opened the Willis C. Campbell Clinic, an institution for the care of his private patients and for the postgraduate training of men desiring to specialize in orthopaedic surgery. The fellowships in orthopaedic surgery which he started in connection with the Willis C. Campbell Clinic in 1924 provided essentially the same training required by the American Board for the Certification of Specialists.

Dr. Campbell was an active member of all of the societies in his specialty and many of the general surgical societies. Among the societies of which he was President are the following: Memphis and Shelby County Medical Society, 1921; Clinical Orthopaedic Society, 1928; American Orthopaedic Association, 1931; and Southeastern Surgical Congress, 1933. He was a member of the Board of Governors of the American College of Surgeons, 1936–1939, and of the House of Delegates of the American Medical Association, 1939–1940. His other professional affiliations included active and honorary membership in many American and foreign societies.

Dr. Campbell played an important rôle in the formation of the American Board of Orthopaedic Surgery and devoted many hours of thought to the problems incident to it. He served as a member of the examining board and was President from 1937 to 1940.

In conjunction with a number of his colleagues, Dr. Campbell envisioned the necessity for an organization in which younger men might receive recognition and identification which would guide their development. It was for this purpose that the American Academy of Orthopaedic Surgeons was founded, and its existence is very largely due to Dr. Campbell who was honored by being made its first President in 1933, and he lived to see the influence which this society in conjunction with the American Orthopaedic Association has exerted in welding the present standards of the specialty.

His capacity for work was almost superhuman, and his interests were widely distributed. He contributed many articles to scientific programs and to various medical journals, also chapters on orthopaedic surgery in many leading textbooks of surgery. In addition to this, he published three volumes: (1) a monograph, "Orthopaedics of Childhood", 1927; (2) a textbook, "Orthopaedic Surgery", 1930; and (3) his last publication, "Operative Orthopaedics", in 1939.

He was one of the pioneers in the development of arthroplasties. He had perhaps the greatest experience in his work on arthroplasty of the knee, and he contributed extensively by his experience with the massive onlay bone graft. Among his original contributions to the specialty perhaps the best known is his bone-block operation for paralytic drop-foot. He was a great believer in the careful analysis of end results and some of his most outstanding contributions to the advancement and development of orthopaedic surgery were contained in the published results of his vast experience.

To enumerate Dr. Campbell's scientific attainments would be to tell the story of only a small part of his full life. He extended kindly and loving guidance over all of the younger men with whom he came in contact; they were inspired by his honesty and integrity, by his unbounded zeal and enthusiasm, by the soundness of his judgment, and by the dominant will with which he overcame obstacles. The words of one of his friends expresses his feeling for him: "To know him was to love him, for his magnetic charm, his sincerety, his strong sense of fairness, and his unfailing kindness and courtesy endeared him to all who came within his ken. Indeed, only a little with him, and one was convinced that here, indisputably, was greatness".

Dr. Campbell's work was his life and he gave his life to it.

WALTER G. STERN

1874–1941

Walter G. Stern was born on December 6, 1874, at Chattanooga, Tennessee, the son of Bernard Stern who took part in the German Revolution of 1848 and came to this country with General Karl Schurz. He received his premedical and his medical education at Western Reserve University, Cleveland, and had postgraduate instruction in orthopaedic surgery under Prof. Adolph Lorenz in Vienna, Austria. In May 1903, he married Miss Lora B. Baer, who with two children, Bernard B. Stern and Mrs. Marjorie R. Schweid, survive him.

In 1903, Dr. Stern started the Mount Sinai Hospital, Cleveland, in a small private house, with twelve beds, and from 1903 to 1935 he served as Orthopaedic Surgeon and Director of Orthopaedic Surgery to both the hospital and the dispensary of this Hospital. In 1907 he occupied the Chair of Orthopaedic Surgery in the Cleveland College of Physicians and Surgeons. About this time he introduced orthopaedic work into both the Rainbow Hospital at South Euclid and the Children's Fresh Air Camp, Cleveland, and when this latter institution was compelled to close its doors in 1908, he helped to found the Holy Cross Home for Crippled Children. In 1914 he became Consulting Orthopaedic Surgeon to the Gates Hospital for Crippled Children and the Elyria Memorial Hospital. At the time of his death he was Consulting Orthopaedic Surgeon to the Mount Sinai Hospital, St. John's Hospital, the Glenville Hospital, and the Bedford City Hospital, Bedford. He was also appointed Orthopaedic Surgeon to the Lutheran Hospital, Cleveland, in 1932.

Dr. Stern was a member of the American Academy of Orthopaedic Surgeons and of the International Society for Orthopaedic Surgery. In 1929 he was President of the Clinical Orthopaedic Society and Chairman of the Orthopaedic Section of the American Medical Association.

In 1907 Dr. Stern was elected to membership in the American Orthopaedic Association, in which society he took an active part, both in presenting papers and in discussions, in the scientific as well as the executive sessions. He was elected Vice-President of the Association in 1917.

His life is a record of many activities and of public service. He began his work in orthopaedic surgery in the early period of this specialty, at a time when it was difficult to obtain the recognition of its place in the field of surgery, and the position it holds today is due in large measure to the work of those men who, like Dr. Stern, established themselves in different parts of the country in the pioneer days of the specialty, and developed the centers of activity from which has spread the rapid growth of this special department of surgery. He was the author of numerous works on the subject of orthopaedic surgery, appearing in various orthopaedic publications within the last forty years.

One was always impressed by his remarkable activity and enthusiasm, and the intensity with which he gave himself to the work in which he was engaged and interested.

He attended the meeting of the American Medical Association in Cleveland and was planning to attend the meeting of the American Orthopaedic Association in Toronto, but died suddenly on the preceding Sunday, June 8.

News Notes

At Commencement at Bowdoin College on June 21, Dr. Murray S. Danforth, of Providence, Rhode Island, was given an honorary degree of Doctor of Science.

Dr. Edward L. Compere announces the association with him of Dr. Sam W. Banks in the practice of orthopaedic surgery. Their offices are in the Lake View Building, 116 South Michigan Boulevard, Chicago.

Dr. C. B. Francisco announces that his nephew, Dr. C. L. Francisco, is now associated with him in the practice of orthopaedic surgery, at 623 Argyle Building, Kansas City, Missouri.

Dr. Eben W. Fiske has moved his office to 725 Jenkins Arcade Building, Pittsburgh, Pennsylvania.

Dr. Theodore H. Vinke announces the association with him of Dr. Charles U. Hauser in the practice of orthopaedic surgery. Their office is Suite 709, Carew Tower, Cincinnati, Ohio.

Dr. Harold C. Bean, of Salem, Massachusetts, has been called to active duty in the Navy and is located at the United States Naval Hospital, Portsmouth, New Hampshire.

Dr. Louis W. Breck announces that Dr. W. Compere Basom is now associated with him in the practice of orthopaedic surgery. Their office is at 410 Roberts-Banner Building, El Paso, Texas.

The Walter M. Brickner Lecture at the **Hospital for Joint Diseases,** New York, was given on May 2 by Dr. Franklin C. McLean, Professor of Pathological Physiology, University of Chicago. His subject was, "Calcification and Ossification: Some Aspects of the Physiology of Bone".

The Twentieth Annual Conference of the **American Physiotherapy Association** is to be held at Lagunita Court, Stanford University, California, July 13 to 18.

The Seventieth Annual Meeting of the **American Public Health Association** will be held at Atlantic City, New Jersey, October 14 to 17. Headquarters for the meeting will be the Convention Hall, and residence headquarters will be the Hotel Traymore.

The Fifth Semi-Annual Meeting of the **Tri-State Orthopedic Society** was held in Fort Wayne, Indiana, on April 19. An interesting program was presented by the orthopaedic surgeons of Fort Wayne and Indianapolis. The next meeting will be held in Cincinnati, Ohio, in September.

The **American Society for the Study of Arthritis** held its Twelfth Annual Meeting on June 5, 6, and 7, at the Deshler-Wallick Hotel, Columbus, Ohio. An excellent program was presented, of special interest being papers by Dr. Edward Harlan Wilson, "Surgical Aspects of Arthritis"; Dr. W. W. Lermann, "Relation of the Gastro-Intestinal Tract to Arthritis", a study based on 5,000 cases; Dr. Reginald Burbank, "Bacteriological and Serological Approach to Diagnosis and Treatment of Arthritis"; and a report on "Chemical Investigations" by Dr. Roland Davison.

The **International College of Surgeons** will hold its Annual International Assembly in Mexico City, August 10 to 14, in response to the invitation of the Mexican Government. Many of the Pan-American countries will send official representatives; sessions will be conducted in both English and Spanish. It is expected that surgeons from England, Holland, Palestine, Portugal, Switzerland, and Turkey will also participate in the meeting. Information about the meeting may be obtained from Dr. Max Thorek, Executive Secretary, 850 West Irving Park Boulevard, Chicago.

The **New England Society of Bone and Joint Surgery** has been formed. Its membership is limited to those surgeons in the New England States who confine their practice to bone and joint surgery, particularly the problems of traumatic surgery. The purpose of the Society is to aid in the advancement in the methods of treatment of these conditions. The membership at present is limited to thirty-five active members. The Society will hold professional and scientific meetings in various centers in New England. The first meeting was held in Boston, June 25, 1941. The officers are: President, Dr. A. Leo Brett; Vice-President, Dr. Joseph S. Barr; Secretary-Treasurer, Dr. Gordon M. Morrison.

On May 27, Dr. Arthur Steindler was honored by an all-day clinic and day of social activities, attended by former assistants and members of the staff of the Department of Orthopaedic Surgery of the State University of Iowa. The gathering included orthopaedic surgeons from all parts of the United States. At this time, a permanent Steindler Alumni Club was formed, which plans to meet annually at the time of the meeting of the American Academy of Orthopaedic Surgeons.

The special feature of the occasion, marking the completion of twenty-nine years of his teaching at the University, was the unveiling and presentation to the University of the portrait of Dr. Steindler, Professor and Head of the Department of Orthopaedic Surgery. The portrait, painted by Sidney Dickinson, was the gift of former students and present staff members. It was presented at a banquet, attended by 265 colleagues and friends, and was accepted by President Virgil M. Hancher of the University.

BRITISH ORTHOPAEDIC ASSOCIATION

The postponed 1940 Annual Meeting of the British Orthopaedic Association was held in Oxford on January 3, 1941, under the Presidency of Prof. T. P. McMurray. The Association dinner was held the same evening at New College. Among many distinguished guests were Sir Farquhar Buzzard, the Vice Warden of New College, Colonel Hugh Cairns, Dr. Charles Bradford, and other members of the American Hospital in Britain.

The meeting, which was well attended, despite severe winter weather and difficulties of travel, was devoted to the presentation of short papers of which the following is a summary:

Late Results of Fracture of the Neck of the Femur. By Mr. A. L. Eyre-Brook and Mr. K. H. Pridie, Bristol.

Forty-seven patients out of a total of seventy-five treated for fracture of the neck of the femur by manipulative reduction and the insertion of a Smith-Petersen nail by the Hey Groves technique had been reviewed by clinical and roentgenographic examination at least one year after the procedure. Bony union was proved in 58 per cent. of patients. In the whole series of seventy-five, there had been a mortality of 5.3 per cent. Aseptic necrosis of the capital fragment had occurred more frequently in patients under thirty years of age. The importance of the fracture-shaft angle of Pauwels was emphasized. If this angle was low (below 30 degrees), the results from nailing alone were poor. It was concluded that a fibular graft should be inserted as well.

THE INDICATIONS FOR EXCISION OF THE PATELLA. By Mr. Norman Roberts, Liverpool.

This communication was based on twenty patients in whom the patella had been excised. He discussed the uses of the patella and emphasized the following points:

1. Recovery of function after excision is not so rapid as is often thought, though it is more rapid than after suture of the patella.
2. After excision, flexion movement is usually full or is possible to at least a right angle; extension is often limited; and the quadriceps is often weaker than normal.
3. Excision is advisable in all comminuted fractures in both young and old patients, and in transverse fractures in middle-aged and old patients.
4. Transverse fractures in young patients should be sutured. If the fragments are markedly unequal in size, it is easier to excise the smaller fragment and to suture the rectus or patellar tendon efficiently to the larger fragment.
5. Derangement of the knee, due to recurrent dislocation of the patella, cannot usually be cured by excision of the patella.
6. Good results sometimes, but not always, follow excision in osteo-arthritis of the knee, particularly if the arthritic changes are mainly in the patellofemoral compartment of the joint.

THE CORRECTION OF SCOLIOSIS. By Mr. G. E. Thomas, Liverpool.

Correction of the deformity had been achieved in the majority of sixteen patients by recumbency on a Thomas frame with longitudinal traction and countertraction applied to the head and legs and "three-point" pressure on the apex of the convexity and the extremities of the concavity. To exert lateral pressure, special pads operated slowly by a screw mechanism of the Thomas-wrench type was employed. Failure to achieve correction had occurred in very high and very low curves; in severe, long-established curves; and in those cases in which there was gross rotation, out of all proportion to the lateral curvature.

TREATMENT OF FRACTURES OF THE EXTERNAL TUBEROSITY OF THE TIBIA. By Mr. W. S. Diggle, Liverpool.

Mr. Diggle reviewed a series of these difficult fractures. For those cases in which there was gross comminution and depression of the fragments, he had found open operation, replacement of the fragments, and screw fixation the most effective treatment. Most of his patients treated in this way had been able to return to work in about six months.

TREATMENT OF COMPOUND FRACTURES OF THE LEG. By Mr. G. K. McKee, Norwich.

The speaker advocated fixed skeletal traction on a Thomas splint for tibial and femoral fractures, both simple and compound. For tibial fractures a Steinmann pin was inserted transversely through the upper tibial fragment and through the os calcis or the lower fragment. The pins were fixed firmly, after reduction by manual traction, to the lateral bars of the Thomas splint by a spiecal clamping device.

For femoral-shaft fractures, one pin was employed below the fracture, fixed in a similar way to the Thomas splint. To avoid undue pressure on the ischial tuberosity or groin, the splint was tied to the end of the bed which was then elevated.

The advantage of this method, in contrast to the "closed-plaster" technique, was discussed in the light of a successful experience with the former on thirty compound and twenty simple fractures.

KIENBÖCK'S DISEASE AND ITS TREATMENT. By Mr. F. C. Dwyer, Liverpool.

The author considered that this peculiar affection of the carpal semilunar is probably due to a fibrosis of the dorsal ligaments attached to the bone, resulting usually from trauma. From an experience with thirty-four patients, in ten of whom the damaged semilunar had been removed, Mr. Dwyer felt that conservative treatment offered the optimum results in a condition which in any event always resulted in a permanently damaged wrist.

Nerve Regeneration and Nerve Grafting. By Mr. J. L. Young, M.A., Oxford.

In a most stimulating discourse Mr. Young outlined the preliminary results of the experimental work, now in progress at the University of Oxford, on nerve regeneration and nerve grafting in rabbits. At the start he warned against complete application of the experimental findings to man, even though they had been very accurately demonstrated in animals.

The need for a qualitative method of comparison between different procedures for nerve repair was emphasized. The rate of growth of new fibers was adopted as a criterion, and a method of estimating it was developed. The rate for rabbits was found to be about four millimeters a day, was the same in all nerves, and approximately the same at all levels. Certain suture material occasioned severe reactions,—for example, catgut and pigmented silk. White silk, woman's-hair sutures, and fibrin "glue" produced the least reaction. Return of function was often rapid, and it was emphasized that such rapid recoveries occurred after full wallerian degeneration,—they were not due to "physiological interruptions" such as can occur after ischaemia, but which clear up even more rapidly. Mr. Young pointed out that the delay between interruption and recovery of a nerve's conduction has three parts:

1. In the juncture scar,—probably about twenty days in man.

2. In the nerve itself, during the growth of fibers down it,—probably at the rate of 2.5 millimeters a day in man.

These two phases comprise the anatomical delay.

3. In the muscle, the functional delay,—about forty to sixty days in man. The delay in the muscle seems to be shorter if the muscle has been denervated for only a short time,—a finding strongly in favor of early suture.

The problems of bridging gaps were discussed. It had been demonstrated that nerves could not be stretched suddenly more than 10 per cent. of their total length; and that increase in length from gradual stretching probably was due to actual growth in length of the nerve, rather than to stretching. For grafting, autografts had given most success in rabbits, and there were some encouraging results from homografts.

It is impossible in this brief space to report adequately the many interesting points which Mr. Young raised. It is hoped that he and his coworkers will shortly publish the results of their studies in detail.

AMERICAN ORTHOPAEDIC ASSOCIATION

The Fifty-Fifth Annual Meeting of the American Orthopaedic Association was held in Toronto, Ontario, Canada, on June 9, 10, 11, and 12, 1941, under the Presidency of Dr. D. E. Robertson. The headquarters were the Royal York Hotel, and the sessions were held at Hart House, University of Toronto.

Monday and Tuesday mornings were devoted to clinical sessions arranged by the local committee, and cases were presented by the following: Dr. A. D. McLachlin, Dr. F. R. Wilkinson, Dr. S. A. Thomson, Dr. W. S. Keith, Dr. A. W. Farmer, Dr. J. L. McDonald, Dr. A. B. LeMesurier, Dr. D. E. Robertson, Dr. R. I. Harris, Dr. H. S. Coulthard, Dr. Gordon M. Dale, Dr. G. D. W. Murray, Dr. F. I. Lewis, Dr. K. G. McKenzie, and Dr. W. E. Gallie.

At the scientific sessions the following papers were presented:

Tuesday, June 10

Afternoon Session

President's Address.

Dr. D. E. Robertson, Toronto.

End-Result Study of the Treatment of Idiopathic Scoliosis.

The Research Committee of the Association—Dr. A. R. Shands, Jr., *Chairman*, Wilmington, Delaware; Dr. Joseph S. Barr, Boston, Massachusetts; Dr. Paul C.

Colonna, Oklahoma City, Oklahoma; and Dr. Lawrence Noall, Research Fellow of the Nemours Foundation, Wilmington, Delaware.

Valgus Deformity of the Knee Resulting from Injury to the Lower Femoral Epiphysis.
Dr. LeRoy C. Abbott, San Francisco, California.

Amputations for Arterial Disease.
Dr. Harry B. Macey, Rochester, Minnesota.
Discussion opened by Dr. A. B. LeMesurier, Toronto.

WEDNESDAY, JUNE 11

Morning Session

Surgical Stabilization of Paralytic Dislocated Hips.
Dr. Halford Hallock, New York, N. Y.
Discussion opened by Dr. R. I. Harris, Toronto.

Hospital Treatment of Chronic Rheumatism.
Dr. Robert B. Osgood, Boston, Massachusetts.
Discussion opened by Dr. J. Albert Key, St. Louis, Missouri.

The Treatment of Acute Osteomyelitis by the Sulfathiazole Drugs.
Dr. Robert W. Johnson, Jr., Baltimore, Maryland.
Discussion opened by Dr. Frank D. Dickson, Kansas City, Missouri.

Fractures and Fracture-Dislocations of the Astragalus.
Dr. Robert D. Schrock and Dr. Herman F. Johnson, Omaha, Nebraska.
Discussion opened by Dr. Oscar Lee Miller, Charlotte, North Carolina.

Treatment of Compound Fractures.
Dr. Philip D. Wilson, New York, N. Y.

Afternoon Session

Symposium on War Subjects.
The Red Cross and London, September, 1940.
Col. George Nasmith.
The Canadian Project for the Preparation of Dried Human Serum for Military Use.
Prof. C. H. Best.
Orthopaedic Experiences with Ex-Soldiers.
Dr. Ross Millar.
Experiences in England, 1940.
Dr. Philip D. Wilson.
Orthopaedics Relating to the United States Army.
Dr. George E. Bennett, Dr. Guy W. Leadbetter, and Col. Norman T. Kirk.
Other speakers in the Symposium were Dr. Gillies and Dr. Kelley.

THURSDAY, JUNE 12

Morning Session

Extension Deformities of the Cervical Spine.
Dr. Lloyd T. Brown, and Dr. John G. Kuhns, Boston, Massachusetts.
Discussion opened by Dr. A. Bruce Gill, Philadelphia, Pennsylvania.

Myxomatous Tumors of the Knee Joint.
Dr. Ralph K. Ghormley, and Dr. Malcolm B. Dockerty, Rochester, Minnesota.
Discussion opened by Dr. Allen F. Voshell, Baltimore, Maryland.

Resection and Transplantation in the Treatment of Bone Sarcomata.
Dr. Dallas B. Phemister, Chicago, Illinois.
Discussion opened by Dr. Willis K. West, Oklahoma City, Oklahoma.

Femoro-Ischial Transplant in Certain Cases of Tuberculosis of the Hips.
Dr. David M. Bosworth, New York, N. Y.
Discussion opened by Dr. Halford Hallock, New York, N. Y.

Vitallium-Mold Arthroplasty (moving-picture demonstration).
Dr. M. N. Smith-Petersen, Boston, Massachusetts.

The Annual Dinner was held at the Royal York Hotel, on Wednesday evening, June 11. The speaker of the evening was Sir Robert Falconer.

At the last Executive Session the following officers were elected:
President-Elect: Dr. Frank R. Ober, Boston, Massachusetts.
Vice-President: Dr. A. B. LeMesurier, Toronto.
Secretary: Dr. Charles W. Peabody, Detroit, Michigan.
Treasurer: Dr. Frank D. Dickson, Kansas City, Missouri.

The following members of committees and delegates were elected:
Membership Committee: Dr. Mather Cleveland, New York, N. Y.
Program Committee: Dr. Myron O. Henry, Minneapolis, Minnesota.
Delegate to the American College of Surgeons: Dr. James Archer O'Reilly, St. Louis, Missouri.
Representatives on the American Board of Orthopaedic Surgery: Dr. George E. Bennett and Dr. Allen F. Voshell, Baltimore, Maryland.

The President for the current year is Dr. George E. Bennett, Baltimore, Maryland. The 1942 meeting will be held in Baltimore, in May.

The following were elected to active membership in the Association:
Dr. Walter P. Blount, Milwaukee, Wisconsin.
Dr. Frederick C. Bost, San Francisco, California.
Dr. A. W. Farmer, Toronto.
Dr. P. M. Girard, Dallas, Texas.
Dr. R. Nelson Hatt, Springfield, Massachusetts.
Dr. Frederick A. Jostes, St. Louis, Missouri.
Dr. Beveridge H. Moore, Chicago, Illinois.
Dr. Jesse T. Nicholson, Philadelphia, Pennsylvania.
Dr. Eugene M. Regen, Nashville, Tennessee.
Dr. John A. Siegling, Urbana, Illinois.
Dr. Paul B. Steele, Pittsburgh, Pennsylvania.
Dr. T. Campbell Thompson, New York, N. Y.
Dr. R. M. Wansbrough, Toronto.
Dr. Edward Harlan Wilson, Columbus, Ohio.

On Tuesday evening a dinner was given at the Toronto Hunt Club by Dr. and Mrs. Robertson, an occasion greatly enjoyed by the members of the Association.

Those who attended the Meeting report that it was one of the best meetings of the Association ever held. Great credit is due the President and members of the Local Committee, Drs. LeMesurier, Farmer, Thomson, McDonald, and Harris, as well as the Program Committee of which Dr. Alan DeForest Smith was Chairman.

Current Literature

Fractures and Other Bone and Joint Injuries. R. Watson-Jones, B.Sc., M.Ch.Orth., F.R.C.S. Ed. 2. Baltimore, Williams and Wilkins Co., 1941. $13.50.

Of all of the comparatively numerous textbooks and volumes of reference on the subject of "fractures and other injuries to the bones and joints" which have appeared within the past ten years, none is more delightfully written or more stimulating in manner of presentation than is this scholarly work by Watson-Jones.

As stated by the author, the first edition of this book was written in days of relative peace. However, that volume included the tested and proved procedures through which the science of orthopaedic surgery, and particularly of fracture treatment, had advanced. This second edition includes material and information obtained by Watson-Jones, through his own experience and that of his colleagues, in rendering aid as civilian consultant orthopaedic surgeon to the Royal Air Force.

The chapter on open and infected fractures and war wounds has been rewritten. Recent developments in chemotherapy, blood and plasma transfusion, the treatment of wound shock, the closed-plaster technique, and the technique of amputation have been considered with finesse and clarity. The quality of the illustrations and of the printing, as was also true of the first edition, is so excellent that they are deserving of special comment. The physiology of the healing of a fracture is beautifully portrayed in a full-page colored photomicrograph, and there are other noteworthy illustrations in color.

After this book, there is little for the modern fracture surgeon to add to the subject. Whether used as a book of reference or a textbook, this is a volume of classical medical writing which will be a valuable and prized addition to the library of the doctor who has any interest in the treatment of fractures or other injuries to the bones or joints.

Arthritis and Allied Conditions. Bernard I. Comroe, M.D. Ed. 2. Philadelphia, Lea & Febiger, 1941. $9.00.

The second edition of this book is better than the first. It has been amplified and brought up to date, especially in regard to gold therapy and sulfanilamide preparations as used today. The text is clear and simple. Many questions asked by the general practitioner have been answered in a practical way by the author's "box form" summaries which are excellent. These make the book very useful for quick reference on almost any subject connected with arthritis on which the physician may wish to refresh his memory.

As a textbook, it presents one of the best reviews so far published. All the usual forms of therapy as used by the experts are carefully described,—massage, baking, exercise, rest, splinting, and surgery. The more recent forms of treatment—such as gold, sulphur, and bee venom—are appraised and given to the reader to use as he wishes after knowing the opinion of the authorities on all the special subjects.

There are additional chapters on backache, feet, sciatica, shoulders, and tumors of the joints. A special chapter on the organization of an arthritic clinic is of real value to the hospital administrator.

The first edition found a place in American medical literature which should be made more secure by this improved second edition. It is well worthy of study by all physicians.

Emergency Surgery. Hamilton Bailey, F.R.C.S. Ed. 4. Baltimore, The Williams & Wilkins Co., 1940. $15.00.

This new edition contains all the good features of the previous editions plus many new ideas. The book is excellent in its clearness, simplicity, and excellence of illustrations. Being a treatise on "emergency surgery" it aims to portray the high lights of all procedures which may have to be done as emergencies. It is so carefully arranged and

indexed that one about to perform an emergency operation could look up the matter in question in a very few minutes.

This edition was published in Great Britain shortly after the onset of the War and for this reason does not contain any new points developed from war surgery. However, it does bring up to date all the new surgical procedures which are of such importance in war surgery. Some of the new subjects treated at length are: intravenous infusions, transfusions, typing, the use of stored blood, the use of the vacoliter and transfuso-vac, peripheral embolism, thrombosis and phlebitis, the use of sulfanilamide in gas gangrene and other infections, and the use of the Miller-Abbott tube.

All the major operative procedures are clearly discussed and illustrated by careful engravings. Many of the more important illustrations are in color. This is by all means the best edition thus far, and one of the finest books we have seen on surgical emergencies.

The Pharmacology of Anesthetic Drugs. John Adriani, M.D. Ed. 2. Springfield, Illinois, Charles C. Thomas, 1941. $3.50.

The eighty-six-page syllabus on the pharmacology of anaesthetics is the first attempt to correlate the physical and theoretical with the clinical features of anaesthesia. It is a book of equal value to clinicians of medicine, surgery, and anaesthesia, and presents physiological and pathological effects of the drugs used in anaesthesia and general medicine on the various organs and systems of the body. The book consists of a compilation of valuable data from periodicals, textbooks, and other sources in the medical and scientific literature, as well as original clinical and laboratory investigation by the author and his collaborators. Many interesting charts and diagrams simplify the book and make it instructive and interesting.

The main issues under consideration are the pharmacology and chemistry of the anaesthetic and non-anaesthetic drugs employed in anaesthesia; the physiology of respiration, with reference to the pathological conditions arising during anaesthesia; the physiological and toxic effects of the gaseous volatile; aliphatic anaesthetic agents, and local anaesthetics used in regional anaesthesia. The use of stimulating drugs used as analeptics is considered separately, as is the use of the inorganic gases, such as oxygen and nitrogen, helium and carbon dioxide.

Other valuable data are presented on preanaesthetic medication, carbon dioxide absorption, complications and accidents during anaesthesia, postanaesthetic sequelae, and anaesthesia and respiratory complications. A section on fires and explosions with anaesthetics and a brief but very valuable bibliography makes the book complete.

Die Wirbeltuberkulose und ihre Heilung (Tuberculosis of the Spine and Its Cure). Dr. med. Julius Friedrich von Finck. Stuttgart, Ferdinand Enke, 1940. 19.60 marks.

Surrounded by the articulate champions of this and that new method, it seems almost superfluous to return to the study of old methods. There is nothing new in the treatment of tuberculosis, however, and the "old timers" had the advantage of seeing much more clinical material than we see today. From an experience of forty years in the conservative treatment of spinal tuberculosis in Russia and Germany, an almost legendary character now summarizes his life work in a monograph which many Americans will find at variance with their convictions. Before and after photographs and roentgenograms of *corrected* deformities compel one's attention to his aphorisms. Tuberculosis is carried to the spine through the lymphatics and usually appears first in the intervertebral disc, and should be treated by compression, not extension. The most important therapeutic measure is generalized muscle relaxation.

The use of plaster beds, with the "cotton cross" making pressure on the gibbus, is only one part of a painstaking technique which is of considerable practical importance to any orthopaedic surgeon. Long pointed to in Europe as a bulwark of steadfast conservatism, the work of von Finck is now recorded in readable form. It should be more than a valuable record to the next generation.

Massage in Nursing Care. Kathryn L. Jensen-Nelson, M.A., R.N. Ed. 2. New York, The Macmillan Co., 1941, $2.00.

The first edition of this book appeared in 1932 under the more satisfactory title "Fundamentals of Massage" and, with some additions, contains "the essential facts in the science and art of massage which the author believes are fundamental in the education of any nurse". This new title "Massage in Nursing Care" is a misnomer, as it fails to cover the phases of massage which are required of the professional nurse.

Set up as a textbook, it assumes that the student nurse, in the minimum required time (seven hours of theory and eight periods in the laboratory) can master the theory and practice of the application of massage, as well as some of the active and passive movements, and learn to make intelligent decisions in arranging her own prescriptions for the treatment of many diseases of the muscular, circulatory, nervous, and gastro-intestinal systems. The brief and generalized descriptions of the care of conditions considered are only sufficient to give the nurse a prefatory interpretation of the value and application of this modality as a part of the treatment of the patient, and certainly should not be interpreted to be sufficient information to equip any worker to treat the various conditions described. The treatment of postural defects, sprains, fractures, arthritis, circulatory disturbances, poliomyelitis and other paralyses according to the standards for physical-therapy training approved by the Council on Medical Education of the American Medical Association, belongs in the hands of a specialist trained in physical therapy, and is not required of the attending nurse.

Notfallchirurgie. Die Ausführung der dringlichen blutigen Eingriffe (Emergency Surgery). Priv.-Doz. Dr. Adolf Ritter. Stuttgart, Ferdinand Enke, 1940. 40.50 marks.

This text constitutes Band 63 of the system of *Neue Deutsche Chirurgie* appearing currently under the general editorial supervision of Sauerbruch. Primarily the work is intended for the general surgeon who is called upon to handle any emergency. The directions for the procedures recommended are interestingly presented in a concise form. The larger part of the work is devoted to subjects which do not especially concern the orthopaedic surgeon. The hundred or so pages which deal with orthopaedic problems are devoted mainly to the treatment of inflammatory conditions. Fractures are but sketchily discussed. The surgery of paralysis and of congenital malformations is, by the nature of the work, completely excluded.

The American Illustrated Medical Dictionary. W. A. Newman Dorland, A.M., M.D., F.A.C.S., with the collaboration of E. C. L. Miller, M.D. Ed. 19. Philadelphia, W. B. Saunders Company, 1941. $7.00 (Thumb-Indexed, $7.50).

The Nineteenth Edition of this book has just appeared. Each edition is welcomed, because of the character and the amount of the new information which it always gives as well as the accuracy with which the advances in the different fields of medicine and surgery have been followed.

It is distinctly a word book, but it is very much more than a dictionary of medical terms and conditions, because of the large amount of information on the different subjects, which gives to the practitioners the data so frequently needed. Information in regard to laboratory methods, tests, etc., accompanies definitions. Under important headings a considerable amount of collateral descriptive matter is appended; for example, under drugs is given information in regard to their origin, their composition, dosage, etc.; under special diseases, information in regard to their etiology, clinical data, often with symptoms added; and this general principle is carried throughout the book in regard to all of the different headings and the later advances, to give more than merely suggestions of the progress in the latter years.

The important data in regard to the pronunciation, derivation, etc., are made a special feature, all of which afford in a brief and convenient form that knowledge of which the busy medical man is in constant need, and he will find the large amount of information contained in the book presented in a practical and convenient form. The illustrations, diagrams, and charts, of which there are a great many, add to the attractiveness and to the interest of the volume.

Field Surgery in Total War. Douglas W. Jolly, M.B., Ch.B.N.Z. New York, Paul B. Hoeber, Inc., 1941. $3.50.

The author commanded a mobile surgical unit in the Spanish War, and the opinions expressed in this book are based on his personal observations of some 4,500 wounded men. The book is divided into two sections.

Section 1 covers the organization and tactical disposition of surgical units in the field. To overcome the "time lag", patients were evacuated to the "Classification Post", one to four miles behind the front. "First" urgency cases were despatched immediately to the adjacent No. 1 Hospitals which, to be effectual, had to be within the five-hour "time lag" from the front. No. 2 Hospitals, which were located farther to the rear, within a ten-hour "time lag", received all other cases except the slightly wounded and sick who were evacuated directly to the sector Evacuation Hospital located at a rail head. The "time lag" to this Hospital was under eighteen hours.

The mobile surgical unit was the basic unit of the three-point forward system. It consisted of a surgical lorry (*auto-chirugire*), and one ambulance for transportation of personnel,—used for evacuation of patients when the team was on station.

Section 2 (more than two-thirds of the book) covers the surgical technique used in the forward areas. The author classifies war wounds into two main groups: (a) those requiring immediate operation for the saving of life (at Hospital No. 1), and (b) those requiring operation as soon as possible for the shortening of the period of disability.

Various types of anaesthesia are discussed and contra-indications are considered. One chapter is devoted to each of the following: wounds of the nervous system; extremities; face, jaw, eye, ear, and neck; chest; abdomen; and genito-urinary system. Gunshot wounds of the abdomen are discussed in detail.

This is a very excellent reference book for the surgeon interested in the evacuation and emergency treatment of war wounds.

Fracturas Recientes del Raquis. Algunos de sus Aspectos (Recent Fractures of the Spine). Dr. José Luis Bado. Montevideo, 1940.

This is a very well organized study of 117 cases of fracture of the spine with excellent illustrations, roentgenograms, colored line drawings, and photographs of postmortem specimens of the spine, etc. The monograph of 152 pages, well printed on very good paper, is divided into several parts:

1. General statistical considerations;
2. Clinical varieties of fractures of the spine;
3. Treatment of recent vertebral fractures without involvement of the roots and spinal cord;
4. Inconveniences and complications of reduction in hyperextension;
5. Physiopathology of injuries of the spine and spinal cord;
6. Laminectomy in the treatment of lesions of the spine and spinal cord;
7. The present status of treatment of fractures of the spine with spinal-cord injuries.

The subject matter is written in a lucid style. Each chapter is followed by a résumé, and the most important findings are printed in large letters. Numerous illustrative ease reports are given in substantiation of the description of the types of fractures and various methods of treatment. The symptomatology of fractures, complications, and the indications for treatment are remarkably complete. The orthopaedic surgeon acquainted with Spanish would find the monograph very instructive and interesting.

Über die Entstehung, Erkennung und Vermeidung der postoperativen Fernthrombose (The Development, Recognition, and Prevention of Postoperative Peripheral Thrombosis). K. Lenggenhager. Leipzig, Georg Thieme, 1941. 2.85 marks.

In this sixty-three-page monograph dedicated to Prof. de Inervain, the writer summarizes an eight-year study of peripheral thrombosis. It is his belief that a thrombosis in the vein begins as an agglutination of the platelets. Injury to the endothelium of the vein plays no part in the localization of the thrombus; this is determined by a local slowing of the blood stream. The precursors of thrombin enter the blood stream from the operative or injured area. Fresh fibrin, which cannot be demonstrated by the Weigert-color reaction, is absorbed by the blood platelets. This agglutination of platelets and fibrin forms the basis of the thrombus. If the lumen of the vein becomes plugged, a red secondary thrombus then appears with only partial closure of the vein.

There is a great individual variation in thrombin formation. Some individuals have a thrombin which is active longer in their blood stream. The livers of different individuals also have a different capacity for the formation and activation of thrombin. Then there is the local slowing of the venous circulation,—more marked in the presence of varicosities and poor circulation.

Prevention of peripheral thromboses hinges upon the hindrance of the resorption of thrombin, and upon measures to improve the local circulation; but the neutralization of the thrombin is the most important. The thrombin resorption reaches its zenith about one hour after the operation.

There exist two antithrombin substances, heparin and hirudin. The latter in larger doses is toxic. The administration of heparin is given in older patients (over forty-five) by injection about the site of the wound at the end of operation; this provides slow absorption for several hours. Or it may be given one hour after operation intravenously, five hours after operation, and finally thirty hours after operation. At the Berlin Clinic since 1935, 9000 patients have been operated upon, and of the 2500 treated with this heparin prophylaxis, none have died of embolus.

Heparin therapy can also be used when the first signs of peripheral thrombosis appear and can be repeated in twelve hours. By this means much, but not all, thrombin in the wound can be neutralized. In addition, the circulation should be stimulated by deep-breathing exercises every half hour, and by passive stimulation with drugs.

Über die subkutane totale Achillessehnenruptur und deren Behandlung (The Treatment of Total Subcutaneous Rupture of the Achilles Tendon). Nils Silfverskiöld. *Acta Chirurgica Scandinavica*, LXXXIV, 393, 1941.

The writer reports four acute and three chronic cases of subcutaneous rupture of the Achilles tendon, reviews the literature, and proposes a plastic operation to reinforce the tendon suture. A flap three to four by ten centimeters of the posterior layer of the Achilles tendon was turned down and rotated on the distal pedicle so that the smooth outer surface remained posterior. It was sutured along the sides and to the attachment of the Achilles tendon. Such good results are obtained by the operative treatment that it should be preferred to the conservative.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

Antituberculous Immunity Produced by B C G Vaccine. J. Zeyland and E. Piasecka-Zeyland. *Acta Paediatrica*, XXVII, 393, 1940.

Zeyland and Piasecka-Zeyland of Posnan, Poland, attempted to determine whether specific immunity was produced by B C G vaccine. Experiments were carried out upon guinea pigs, giving to twenty animals twenty milligrams of a two-weeks-old B C G culture with two cubic centimeters of fluid intraperitoneally. In four weeks the intracutaneous tuberculin reaction was positive in these vaccinated animals. Subsequently all of the animals were given 0.01 milligram of a four-weeks-old culture of human tubercle bacilli.

and lower tibiofibular joints, stating that the advantages are that the entire blood supply to the shaft of the fibula is left intact, that the surgical approaches are outside the field of infection, if present, and that if a tibial graft is used, the fixation and stabilization will be greater. Fifteen cases are reported, five being due to hematogenous osteomyelitis, nine to fractures, and one to a pathological fracture following osteomyelitis. Eight cases were treated by fibular osteotomy and transplantation by the Huntington method, three by tibiofibular fusion, and three by combined fusion and osteotomy, with a fibular graft used in the same leg in one case. In five cases, recurrent drainage occurred, and in three, temporary peroneal nerve palsy resulted. The table of results indicates good results and the technique is clearly discussed. Weight-bearing should not be attempted until from six months to a year after the second stage of the operative procedure, and then with adequate support until the clinical and roentgenographic evidences of union are adequate for weight-bearing in each case. Good results were obtained in thirteen of the fifteen cases reported.—*Custis Lee Hall, M.D., Washington, D. C.*

A Critical Appraisal of the Leg Lengthening Operation. Beveridge H. Moore. *American Journal of Surgery*, LII, 415, June 1941.

End results of bone-lengthening procedures in fifty-two cases are studied with particular emphasis on gait and function of the extremity. Forty-one were in the lower leg, of which the cause of shortening was poliomyelitis; two were congenital; and two were due to epiphyseal damage from manipulative treatment of club feet. Nineteen of the patients operated upon since 1929 were considered to have passed the rapid growth of adolescence. The lengthening was from one and one-half to two and seven-eighths inches, as checked on roentgenograms. Consideration was given to maintenance of length, secondary development of deformity, changes in muscle power, and gait or function. Maintenance of length was quite uniform and three patients showed more rapid growth than the normal leg; and one, failed to maintain the leg equality. Improvement was, of course, noted in postural balance, due to leveling of the pelvis and lessening of scoliosis. Knock-knee and valgus of the foot was increased in eight patients, and some loss of ankle function was noted, also changes in gait from greater strain on the weakened hip abductors. Studies of the gaits of these patients showed that six were improved, nine were not improved, and four were worse, which led to the conclusion that the two elements of shortening and muscle weakness must be carefully evaluated, so as to make a more careful selection of cases.

Patients with weak hip fixators and quadriceps accounted for most of the less satisfactory results. No cases of non-union were found, only one case of bone infection, and only moderate bone displacement in the fragments. Foot displacement occurred in two cases, and foot stabilization was done after the lengthening was complete. Nerve disturbance of a temporary character was seen in two cases.

Contra-indications are old osteomyelitis and epiphyseal injuries where length cannot be maintained. In congenital shortening each case must be considered separately. The author does not consider the operation feasible in patients without enough power to walk without a brace. Best results are in poliomyelitis cases with enough power in the gluteus muscles to fix the pelvis against gravity when walking, and sufficient quadriceps power to extend the knee with several pounds' resistance to the ankle. In doubtful cases, the shoe should be built up to equal the proposed lengthening, and the resultant gait observed.—*Custis Lee Hall, M.D., Washington, D. C.*

Guide for Internal Fixation of Intracapsular and Intertrochanteric Fractures of the Femur. I. W. Kaplan. *The American Journal of Surgery*, LII, 443, June 1941.

Mechanically, the guide consists of a metal frame with V-shaped ends, notched at the bottom. One end is held at the juncture of the shaft of the femur and the greater

trochanter by the notched ends and the other below on the shaft of the femur. A handle is used to hold the guide and indicate thus the horizontal plane. The director is a square piece of metal between the two V's and guides the wire or drill. It is set on a pivot which can be adjusted at any angle, and set by a screw on its undersurface. The director is equipped with three openings so that double screws or a single wire may be used. The top half can be removed if two screws are used. An angle guide is used, and for most cases is set at 127 degrees, and 20 degrees of internal rotation allows for horizontal-plane adjustment of the device. This procedure has been employed in thirty-eight cases, and operative time has been reduced to from thirty-five to forty minutes.—*Custis Lee Hall, M.D., Washington, D. C.*

TREATMENT OF FRACTURES OF THE SHAFT OF THE FEMUR BY DOUBLE WIRE TRACTION. H. A. Swart. *American Journal of Surgery*, LII, 507, June 1941.

The use of skeletal traction in fractures of the shaft of the femur is reviewed. In the author's experience since 1935, the use of a Kirschner wire through the distal fragment and a Thomas splint with Pierson attachment resulted in upward bowing which persisted in spite of change of angle or manipulation, and usually resulted in open reduction. By the use of a second wire, placed through the proximal end of the distal fragment, and downward traction, reduction was obtained. In cases of displacement of the distal fragment posteriorly, traction with the second wire upward produced the necessary reduction. Six cases are reported, and two additional cases are mentioned, in which a third wire was used with a ventral pull on the distal end of the proximal fragment and a dorsal pull on the proximal end of the distal fragment. Results were reported as good.—*Custis Lee Hall, M.D., Washington, D. C.*

A REVIEW OF 58 CASES OF TABETIC ARTHROPATHY. Maurice M. Pomeranz and Abraham S. Rothberg. *American Journal of Syphilis, Gonorrhea, and Venereal Diseases*, XXV, 103, Jan. 1941.

The authors describe fifty-eight cases with unquestionable roentgenographic evidence of tabetic arthropathy, of the ninety which were seen at the Hospital for Joint Diseases during the past ten years. About 72 per cent. of the cases occurred in white males.

Of the nineteen cases with multiple involvement, in two the spine and hip joints were involved; in one, the knee and foot; in one, the hip and knee; and in one, the hip and pelvis. There were twelve instances of bilateral disease, in three of which the hips were affected; in four, the knees; and in five, the feet. Where bilateral disease occurred, the parts were not affected simultaneously.

In contrast to the generally accepted view, the authors found that pain was frequently a prominent feature—in many instances the sole reason for reporting to the hospital—that motion frequently increased the pain, and that rest gave great relief. They no longer believe that lack of pain is of diagnostic importance. It is probable that the persistence of pain is due to an incomplete destruction of the pain fibers in the column of Goll and Burdach or in the spinal thalamic tract. Absence of the knee jerks, the Argyll-Robertson pupil, ataxia, and the Romberg test, in this order, are the neurological criteria which substantiate the diagnosis. It is just as important to repeat the neurological examination as the serological tests, as definite signs of tabes may ultimately develop. Only 62 per cent. of the patients had positive serological tests, and a relatively high proportion were completely negative. In spite of the greater value of the spinal-fluid examination in tabes, spinal taps were not performed so frequently as blood tests.

The authors agree with many other observers that the roentgenogram often provides the first clue to the existence of syphilis. In the early manifestations of the disease the most constant finding is the accumulation of fluid within the synovial sac, but of greater

importance is the presence of a slight sclerosis of the bones comprising the joint, which may be so slight as to be overlooked or misinterpreted by the inexperienced.

In the advanced stages of Charcot's disease, there may be no osteoporosis, but in the early stage of the disease when pain is usually present, there is a variable degree, the roentgenographic appearance of which is considerably modified by the associated syphilitic osteosclerosis.

Callus formation may be excessive where the fractures extend into the shaft, but scanty or absent where articular surfaces are involved. There may be intramuscular or ligamentous ossifications of varying degree, forming a cuff of bone around the joint, most characteristically about the knee and hip.

The differential diagnosis is chiefly concerned with the elimination of syringomyelia as a causative factor. Although the diagnosis of a neuro-arthropathy solely by the roentgenogram could be made without great difficulty as a rule, certain diseases at times simulated this condition rather closely. Chief among these were osteo-arthritis, pyarthrosis, neoplasms, and fractures about the joints.

In this group of cases twenty-one operations were performed on eighteen patients, two of whom died following knee fusions. Although a total of eleven fusion operations were performed, the only satisfactory results were obtained in the cervical spine, and one knee. It is too early to determine the outcome of one fusion operation in the lumbar region.

CRITERIO FUNCTIONAL EN EL EXAMEN PERICIAL DE LOS FRACTURADOS (Functional Criteria in the Critical Examination of Patients with Fractures). Oscar R. Maróttoli. *Anales de Cirugia*, VI, 369, 1940.

This article is an excellent discussion of how to grade a patient who has had a fracture, and who is ready to return to work. The author brings out the point that in the evaluation of residual disability in the final results from a fracture, the patient should be looked at from a broad point of view, including his ability both to do the kind of work he had been doing, and to adapt himself to a new type of work. He quotes a legal decision in support of this idea, and stresses the point that what he calls a physiological end result is very much more important than the anatomical result. We are all too prone to look at a roentgenogram and decide how much disability a man has, following a fracture, while in reality the roentgenogram is only a small part of the entire examination. Often those patients with roentgenograms which show quite a marked anatomical abnormality will have an excellent functional result. On the other hand, some patients in whom the roentgenogram reveals little or no anatomical disturbance have a great deal of loss of function in the extremity. This is particularly true of the upper extremities. The author quotes McBride in saying that there are three fundamental factors in the evaluation of the end result: mechanical and physiological alterations, the actual functional loss, and how much the patient can compensate or readjust for the loss. Another important factor which McBride points out is the possibility of the patient's receiving financial compensation for his injury. The author again stresses the fact that functional efficiency is much more important than the actual anatomical changes and presents several cases of fractures to illustrate his point. The article is a very good treatise on the critical evaluation of the end result in a patient with a fracture.—*Louis W. Breck, M.D., El Paso, Texas.*

PROTRUSIÓN ESENCIAL DEL ACETÁBULO (Protrusio Acetabuli). Oscar R. Maróttoli. *Anales de Cirugia*, VI, 395, 1940.

The author starts his discussion by saying that intrapelvic protrusion of the acetabulum is relatively infrequent, and, to his knowledge, there had been reported, up to the time of his article, only one other case in Argentina. The author presents two more cases whose histories are given in some detail. The first case was that of a woman, aged thirty, who had had pain in the hip for about one year. Examination revealed a good

deal of limitation of abduction and a moderate limp. Roentgenograms showed a bilateral protrusio acetabuli which was much worse on one side than the other. The second case was that of a twenty-three-year-old male who had likewise had pain in the hip for about one year. Examination of this patient revealed considerable limitation of motion in all directions with the limb held in flexion and adduction. Roentgenograms showed a marked intrapelvic protrusion of the acetabulum on one side, and a very slight degree of the same condition on the other. Following the case reports, the author describes briefly the condition with its pathology, the history of the discovery and recent advances in knowledge about it, and gives two classifications for intrapelvic protrusion of the acetabulum. The first classification is that of Golding, who divides cases into three groups; and the second is that of Julio Diez of Argentina, who simply divides the condition into two main types,—secondary protrusions and essential protrusions. The author is of the opinion that the intrapelvic protrusion of the acetabulum occurs usually without arthritis, but that arthritis deformans invariably begins in these patients after the age of fifty. He points out, however, that Ingerfeld reported a case with arthritis deformans in a patient with intrapelvic protrusion of the acetabulum at the age of twenty-one years, while one of the author's own patients was only twenty-two years old. The article is a very good discussion of the subject of protrusio acetabuli and the cases presented have good roentgenographic illustrations.—*Louis W. Breck, M.D., El Paso, Texas.*

Extraskeletal Ossifying Tumors. Harwell Wilson. *Annals of Surgery*, CXIII, 95, Jan. 1941.

Mesoblastic tumors containing bone occur, which have no connection with the skeleton. The author reports ten such cases and gives a synopsis of thirty cases of bone-forming malignant tumors in the soft tissues described in the literature.

Four of the ten cases reported were osteogenic sarcomata; one, a fibrosarcoma with degeneration, calcification, and heterotopic bone formation; one, a chondrosarcoma; one, a bursal sarcoma, with ossification in the primary tumor; one a case of von Recklinghausen's neurofibromatosis, with ossification in a neurofibroma; and two were fibrous osteomata.—*O. B. Bolibaugh, M.D., San Francisco, California.*

Russell Traction in the Treatment of Fractures of the Femur. Observations of One Hundred Fifty-Six Cases. Kenneth M. Lewis. *Annals of Surgery*, CXIII, 226, Feb. 1941.

The author reviews the evolution of the treatment of fractures of the femur and points out the disadvantages of the various methods. The Russell method was adopted by the Fourth Surgical Division of the Bellevue Hospital in January 1930, because of lack of satisfaction with results obtained by skeletal traction. One hundred and fifty-six cases are reported in which this method was used: eighty-five intertrochanteric, twenty-three in the upper third of the shaft, eighteen in the middle third of the shaft, and thirty in the lower third of the shaft. Adequate reduction could not be obtained in seven cases, of which three were in the upper third and four in the lower third of the shaft.

Seventy-four cases were men and eighty-two, women. The youngest was fourteen years of age, the oldest eighty-six. The average period of traction was seventy-eight days, the shortest forty-two days and the longest one hundred thirty-five days. The weight used for traction varied from five to ten pounds. Reduction was checked by roentgenograms rather than by external measurements. There were six deaths, all in old individuals and caused by senility and bronchopneumonia. One hundred and forty-three cases which were treated by Russell traction alone were followed to an end result.

Reduction was easily accomplished and overriding corrected. Union was obtained in all instances. Traction was maintained until union was demonstrated clinically and by roentgenograms. The author states that few cases should be allowed unsupported weight-bearing under six months. Joint function was recovered more rapidly when this method was used.

The author concludes that Russell traction is the method of choice in intertrochanteric fractures and for all those involving the shaft. He recommends open reduction and internal fixation with a Lane plate when muscle interposition is present. The method is not recommended for intracapsular fractures of the neck of the femur. He believes that skeletal traction should be discarded as a procedure in handling femoral fractures.—*O. B. Bolibaugh, M.D., San Francisco, California.*

Observations on Tuberculous Disease of the Spine in Madras. N. S. Narasimhan. *The Antiseptic*, XXXVII, 698, 1940.

The author discusses his observations on tuberculous disease of the spine in Madras, where in the past three years he has treated 188 cases of vertebral tuberculosis as against 195 cases of tuberculosis of all other bones. The maximum incidence was in children between two and five years, and boys were more often affected than girls. The majority of cases were in the thoracic region, with the eighth to the twelfth thoracic vertebrae most often involved, and the twelfth thoracic vertebra more often affected than any other. The lesions were more often central than periosteal. Multiple infections of the vertebrae were common, and the articulations of the heads of the ribs were often involved.—*Robert M. Green, M.D., Boston, Massachusetts.*

Dislocation of the Radius Associated with Fracture of the Upper Third of Ulna. M. G. Kini. *The Antiseptic*, XXXVII, 1059, 1940.

Kini reports a series of 330 elbow injuries, in ten of which dislocation of the radial head was associated with fracture of the upper third of the ulna. One of these cases showed radial paralysis. The author describes his technique of reduction, and recommends excision of the radial head when persistent redislocation occurs.—*Robert M. Green, M.D., Boston, Massachusetts.*

Fractured Rib with Some of Its Complications. B. N. Sinha. *The Antiseptic*, XXXVI, 1083, 1940.

Sinha discusses the complications of rib fracture from direct and from transmitted violence. In the former, he recommends operative intervention to repair intrathoracic damage. The latter are best treated by immobilization with strapping for a period of from three to five weeks.—*Robert M. Green, M.D., Boston, Massachusetts.*

Rôle of Small-Pox in the Production of Deformities By Causing Infection of Bones and Joints. M. G. Kini and P. Kesavaswamy. *The Antiseptic*, XXXVIII, 169, Mar. 1941.

Kini and Kesavaswamy call attention to the occasional rôle of smallpox in the production of deformities by causing infection of bones and joints. During the past decade, the authors have seen twenty-one cases of osteomyelitis or arthritis associated with smallpox, and four with vaccination. The arthritic cases all ended in ankylosis. In the four cases of elbow ankylosis, excision gave satisfactory results. In all the hip cases pathological dislocation occurred, with absorption or other changes in the head and neck of the femur. The article is well illustrated and there is an excellent review of the literature.—*Robert M. Green, M.D., Boston, Massachusetts.*

Congenital Elevation of the Scapula. Alan DeForest Smith. *Archives of Surgery*, XLII, 529, Mar. 1941.

The fifty cases of congenital elevation of the scapula seen at the New York Orthopaedic Hospital from 1912 to 1939 are tabulated and analyzed statistically. The de-

velopment of the deformity is traced phylogenetically, and the omovertebral structure is shown to be the homologue of the suprascapular bone found in several lower vertebrates. Surgical treatment was used in 28 per cent. of the cases and consisted of essentially three procedures: (1) removing the omovertebral connection; (2) freeing of the scapula subperiosteally, with excision of the upper part of the bone; and (3) freeing the bone and anchoring it at a lower level by suturing it to a rib. In general it was found that a number of patients were not sufficiently deformed to warrant surgery, but in the more severe forms of this condition the operative correction afforded improvement in a fair percentage of the cases.—*I. William Nachlas, M.D., Baltimore, Maryland.*

FRACTURES AND DISLOCATIONS OF THE CERVICAL PORTION OF THE SPINE. WITH A REVIEW OF EIGHTY-NINE CASES. William Arthur Clark. *Archives of Surgery,* XLII, 537, Mar. 1941.

In the study made of a series of eighty-nine fractures and dislocations of the cervical spine, it was found that minor trauma can produce dislocation alone, but that automobile accidents are responsible for most of the fractures. Neural complications were recognized by the presence of symptoms varying from slight tingling of the fingers to complete paralysis. Most of the injuries were found to be in the region of the fifth and sixth vertebrae.

Treatment consisted of various procedures: "extension of the head", followed by ambulatory support; manipulation, and application of cast; skeletal traction; and "expectant" (in cases of shock). The author feels that early reduction of the lesion is essential, since it may avoid a permanent paralysis through pressure on the cord.—*I. William Nachlas, M.D., Baltimore, Maryland.*

SECONDARY INFECTION IN TUBERCULOUS SINUSES. R. B. McMillan. *British Journal of Surgery,* XXVIII, 415, Jan. 1941.

From a study of non-pulmonary abscesses or sinuses in 132 patients, it was learned that tuberculous abscesses are free from secondary infection until they break through or are incised. A secondary infection was present in 90 per cent. of the sinuses studied; streptococci, staphylococci, and diphtheroid bacilli were predominant in that order.

Secondary infection seemed to occur from the surrounding skin, from neighboring sinuses, or from "droplet" infection, particularly if the organism was the streptococcus. The beta hemolytic streptococcus was the only organism that had any serious effect on the patient, but when this was present the prognosis became more grave, the period of hospitalization was increased, and the general health of the patient became poorer. In a few instances it was evident that the local and general spread of the tuberculosis had increased.

The secondary infection had no effect on the healing of the sinuses, which healed when and if the primary focus healed.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

CARTILAGINOUS TUMOUR OF THE SHAFT OF THE ULNA. T. Vibert Pearce and Douglas H. Collins. *British Journal of Surgery,* XXVIII, 432, Jan. 1941.

This is a case report of a cartilaginous tumor of the shaft of the ulna, appearing in a boy of sixteen, apparently after being hit by a cricket ball. The lump was noticed the same day that the trauma occurred, but there was "no bruising" of the arm. He applied for treatment two months later because of pain in the forearm, difficulty in writing, and limitation in pronation of the wrist.

A roentgenogram showed "a rarefied tumour expanding the cortex of the ulnar shaft on its dorsolateral aspect". On admission for operation six weeks later, there had been a marked increase in size of the tumor. The tumor was separated from the extensors of the thumb, outlined above and below by saw cuts, and removed with a chisel.

The tumor was partly covered by cortical bone with normal bone lying between it and the medulla, and was composed of adult cartilage in the deep layer, a small zone of foetal type of cartilage, a zone of myxomatous connective tissue, and finally a segment of collagenous fibrous tissue. Microscopically, no mitoses were seen. It was considered that this was a benign tumor beginning to show malignant changes.

Normal function was gained, and three years later there was no recurrence.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

Tratamiento Quirúrgico de los Tumores de Células Gigantes de los Huesos (Surgical Treatment of Giant-Cell Tumors of the Bones). Alberto Inclán. *Cirugía Ortopédica y Traumatología* (Habana), VIII, 63, 1940.

The author reports a series of cases to demonstrate and explain the different surgical procedures to be considered in the treatment of giant-cell tumors of the bones. In two of these cases, the tumor was located at the patella, a very rare type which has been reported only fourteen times in the literature.

Bone tumors presenting a benign aspect, clinically, roentgenographically, and pathologically, may be treated by curettage, curettage with bone graft, or removal and bone graft on condition that the whole tumor is removed, and primary cicatrization is obtained.

Mass resection is indicated in recurrence of local malignancy, and in the so-called "aggressive type" when its malignancy is confirmed clinically and roentgenographically, as well as pathologically. The bone defect must be filled in order to maintain the form and length of the bone and to assure weight-bearing, even at the expense of some degree of limitation of movement of the joint or, if unavoidable, of total loss of movement.

Amputation should never be performed, except on those patients who are referred to the surgeon too late, or who are bearers of a secondary infection following unsuccessful curettage, or when there is no doubt regarding malignancy, as in bone sarcoma.

Estado actual de la Cirugía de la Cadera en las insuficiencias inveteradas con gran claudicación (On the Present State of Hip Surgery in Severe Limping). René Charry. *Cirugía Ortopédica y Traumatología* (Habana), VIII, 37, 1940.

The author analyzes the conditions favoring the development of severe limping, and stresses that an efficient treatment must be logical and directed against each of its three elements: limp, pain, and fatigue. On the grounds of these results, he recommends a low shelf osteotomy of support, straightening osteotomy, shortening of the extremities for inequality in length, and drilling of the neck in arthritis deformans.

He follows his own technique, when establishing the low shelf without section of the glutei, and employs the wire method and malleable osteosynthesis plates for osteotomy.

The drill hole is centrally placed, and dead bone is used for nailing.

For the shortening of the sound limb, he uses his own technique which is a modification of that employed by Hugo Camera.

The results are excellent from the point of view of appearance.

For malunion of fractures of the femoral neck, he employs the same methods as for congenital dislocation, but obtains better function of the limb by using the trochanteric osteotomy.

The Treatment of Fracture of the External Tibial Condyle (Bumper Fracture). Joseph S. Barr. *Journal of the American Medical Association*, CXV, 1683, 1940.

This type of injury is due to a blow on the anterior aspect of the knee, a fall from a height, or a twisting injury. The fracture is a comminuted one, with a large triangular fragment which is laterally displaced, and several smaller central fragments which are compressed downwards. The treatment is divided into three types according to the severity of the injury:

1. When the depression of the condyle is less than one-quarter inch, the leg is immobilized until the swelling in the knee subsides, then mobilization is carried out. When weight-bearing is resumed, a brace with knock-knee pad is applied and used for from two to six months.

2. When the condyle is depressed one-quarter to one-half an inch, it is considered a borderline case. Results are about equally good in patients treated conservatively and those operated upon.

3. When the depression is over one-half an inch, surgical restoration is advised. Through a curved lateral parapatellar incision the knee joint is exposed first. Then the fracture site is exposed by subperiosteal stripping, and fragments replaced so that the articular surface is restored. While held in this position, they are fixed by passing a bolt transversely through the fragments and upper end of the tibia. In the cases so treated, good results were obtained.—*L. J. Levy, M.D., Dallas, Texas.*

Treatment of Fractures of Ulna with Dislocation of Head of Radius (Monteggia Fracture). J. S. Speed and Harold B. Boyd. *Journal of the American Medical Association*, CXV, 1699, 1940.

In discussing the Monteggia fracture, the authors emphasize the strong tendency toward radial deviation at the ulnar fracture site with subsequent subluxation or recurring dislocation of the radial head. In treatment of acute fractures in adults, closed reduction can frequently be satisfactorily accomplished, but seldom gives good final results because of the radial angulation at the ulnar fracture site with subsequent subluxation of the radial head. For this reason, they prefer open reduction, fixation of the ulnar fragments with a vitallium plate, and the securing of the radial head firmly with a fascial sling. This procedure is performed readily by the exposure the authors have devised, and without injury to the radial nerve. In acute fractures of this type in children, closed reduction is frequently satisfactory, but if reasonable reduction is not obtained, surgery is advisable.

In treating cases of non-union and malunion at the ulnar fracture site, an onlay graft, fixed with vitallium screws, is their method of choice. If the radial head is too roughened or cannot be reduced, the authors excise it. They have not found the results following excision of the radial head to be of sufficient moment to contra-indicate the procedure.—*Louis J. Levy, M.D., Dallas, Texas.*

Treatment of Compound Fractures in War. Reports of Practical Experience in the Spanish Civil War. Leo Eloesser. *Journal of the American Medical Association*, CXV, 1848, 1940.

Due to the difference between modern methods of warfare and those of years ago, the war surgeon found it necessary to revise his methods of treatment of the war injured. Means had to be discovered for rapid evacuation of patients with a minimum of post-operative care.

The author found that chlorinated lime was the most satisfactory, easily procurable and easily transportable skin disinfectant. The surgeon works a paste of chlorinated lime into the hands and often has only a thin trickle of water for rinsing purposes. Finally alcohol, or iodine-alcohol, or a mercurial in alcohol-acetone is used. The patient's skin is prepared with this chlorinated-lime paste, followed by iodine. Large drapes are dispensed with, and small yard-square drapes are used to surround the operative area.

Morphine, procaine, evipal, and pentothal sodium are used together with light ethyl chloride for anaesthesia. Roentgenograms are not used at all at the front as most injuries are compound and condition and position of fragments are revealed at the time of débridement.

The author favors thorough débridement and allowing the wound to remain open. He warns against placing sutures in the depths of the wound.

He discusses in great detail the emergency treatment of nerves, tendons, and damaged vessels, and the application of plaster splints and casts.—*Maurice Jacobs, M.D., Dallas, Texas.*

Spontaneous Reduction of Cervical Spine Dislocations. J. T. Nicholson. *Journal of the American Medical Association*, CXV, 2063, 1940.

The author first presents a thorough discussion of the anatomy, etiology, and diagnosis of cervical-spine dislocations, with special reference to the upper portion of the cervical spine.

In reducing these dislocations, the author's method is to place the patient on his back on three mattresses so that his head hangs free over the upper edge. In such a position the weight of the head acts as traction, and this pull in the hyperextended position "spontaneously" reduces the dislocation.

The author found that this procedure was most satisfactory for spontaneous dislocations. It did not work well in traumatic cases, and in these, the hazard of increasing cord oedema by the dependent position contra-indicates this method during the first one to two days following injury. Posterior dislocation is also a contra-indication. A complication encountered was oedema of the scalp in one patient.

After reduction is accomplished, in forty-eight to seventy-two hours, a head and body plaster jacket is applied and kept on for twelve to sixteen weeks. This is followed by a Thomas collar which allows the strengthening of the neck muscles before leaving off all support.—*Louis J. Levy, M.D., Dallas, Texas.*

Early Operation (Spine Fusion) in Unstable Lumbosacral Joints. Gilbert E. Haggart. *Journal of the American Medical Association*, CXV, 2129, 1940.

The author again calls attention to the almost unlimited possibilities of interpretation of backache, and the lack of agreement among surgeons in regard to the pathogenesis of low-back pain. He groups the cases as follows: Group I, older persons who have received conservative treatment over a period of years; Group II, younger patients treated by arthrodesing operations. No case was included which suggested the diagnosis of ruptured intervertebral disc.

The author discusses the subject of congenital anomalies of the low back, and states his adherence to the belief that such anomalies do produce symptoms through faulty mechanics or when the ligaments and muscles become "decompensated". He lists the mechanical faults as unstable lumbosacral facets, bone defects in the posterior elements of the lumbosacral vertebrae, transitional vertebrae, spondylolisthesis, abnormally acute lumbosacral angle and posterior displacement of the fifth lumbar vertebra on the sacrum, and narrowing of the lumbosacral disc.

He concludes that most patients who do not respond to conservative treatment should be fused. In retrospect, he concludes (1) that patients receiving compensation should not be fused until after a settlement has been made; (2) that no emotionally unstable or psychiatric patients should be fused; and (3) that elderly patients should not be fused.—*Maurice Jacobs, M.D., Dallas, Texas.*

Diastasis of the Distal Tibiofibular Joint and Associated Lesions. Rufus H. Alldredge. *Journal of the American Medical Association*, CXV, 2136, 1940.

This type of injury is usually associated with extensive ligamentous rupture, and results from external rotation on abduction injuries at the ankle. It may or may not occur with a fracture.

The author briefly discusses the anatomy of the distal tibiofibular and ankle joints, and indicates that there is an upward gliding motion of the fibula on the tibia in dorsiflexion of the foot, resulting in a widening of the mortise; and a downward motion of the fibula on plantar flexion, with a narrowing of the mortise.

The diagnosis is made by roentgenogram, which shows a widening of the space between the internal malleolus and the internal aspect of the talus, and indicates a rupture of the internal lateral ligament and tibiofibular diastasis.

Treatment consists of reduction, closed or, if this is impossible, open, with internal fixation and immobilization for from twelve to sixteen weeks.—*Maurice Jacobs, M.D., Dallas, Texas.*

IMPROVED TECHNIC FOR REMOVAL OF SEMILUNAR CARTILAGE AND POSTOPERATIVE TREATMENT. Harold R. Bohlman. *Journal of the American Medical Association,* CXV, 2243, 1940.

In discussing his technique for removal of semilunar cartilages, the author believes that local anaesthesia is preferable to spinal or general anaesthesia; he does not employ a tourniquet for the operation. A careful study of the patient is carried out before surgery, with special reference to bleeding time, clotting time, etc., and complete hemostasis is obtained during operation by means of electrocautery. Aspiration of the joint, followed by air injection, is sometimes done at the close of the operation, and frequently when the sutures are removed on the sixth day. Motion and partial weight-bearing are started at this time. Recovery is usually complete in three weeks.—*Brandon Carrell, M.D., Dallas, Texas.*

THE MEDICAL MANAGEMENT OF FRACTURES. Charles F. Nelson and Roland C. Nelson. *Journal of the American Medical Association,* CXVI, 184, Jan. 18, 1941.

The authors offer some suggestions as to the medical management of fractures, based on the study and management of 1,000 fractures without a failure in union, on the forced regeneration of some fractures with greatly delayed union, cases of osteoporosis, Paget's disease, etc., and on animal experimentation.

They recommend blood-chemistry determinations early in all fracture cases, so that accurate medical management can be instituted. The object of the medical management is to establish a serum-calcium concentration of from ten and five-tenths to twelve milligrams per 100 cubic centimeters, and a serum phosphorus of from three and five-tenths to four milligrams with a calcium-phosphorus ratio of three to one. In addition to milk and calcium medication (one quart of milk daily, calcium gluconate intravenously and four grams of powdered calcium gluconate in four ounces of water twenty minutes before meals), they suggest the use of parathyroid solution to assist in calcium metabolism. For phosphorus metabolism a diet high in phosphorus (liver, eggs, fish, cheese, etc.), supplemented by vitamin D, is advised. A normal amount of free hydrochloric acid in the stomach is necessary to assure absorption of calcium and phosphorus.—*Brandon Carrell, M.D., Dallas, Texas.*

CEREBRAL SPASTIC PARALYSIS. THE OBSTETRIC HISTORY OF ONE HUNDRED AND EIGHTY-FIVE CASES. Gerald W. Gustafson and George J. Garceau. *Journal of the American Medical Association,* CXVI, 374, Feb. 1, 1941.

The authors reviewed the birth history of 185 children with cerebral spastic paralysis. They found prematurity, with its associated fragility of the arteries, to be one of the most frequent etiological factors. Anaesthesia and analgesia were of little importance, and are sometimes definitely useful in preventing cerebral damage. The birth history was normal in the majority of cases, and many infants had no clinical evidence of respiratory difficulty following birth. In these cases, the authors assume an actual lack of cerebral development as the cause of spastic paralysis.

The authors conclude from their results that proper management of labor constitutes the best prevention of spastic paralysis. This is especially emphasized in restricting the use of solution of posterior pituitary, which was an etiological factor in 13 per cent. of

the series. The authors feel that the prevention and treatment of premature labor is the greatest single factor in prevention of cerebral injury.—*Louis J. Levy, M.D., Dallas, Texas.*

MODERN TREATMENT OF COMPRESSION FRACTURE OF THE SPINE. P. C. Sanyal. *Journal of the Indian Medical Association*, X, 105, 1940.

Sanyal presents an interesting discussion of the modern treatment of compression fractures of the vertebral bodies. He describes his technique of hyperextension with suspension, but fails to mention the Rogers apparatus so effectively used in this country.—*Robert M. Green, M.D., Boston, Massachusetts.*

PATELLAR ADVANCEMENT OPERATION. A REVISED TECHNIC. Fremont A. Chandler. *The Journal of the International College of Surgeons*, III, 433, 1940.

In spastic paralysis the abnormally "high patella", resulting from elongation of the patellar tendon, has been successfully corrected by transplanting the bony insertion of the ligament downward. It has, however, been found that there may result an arrest in the growth of the anterior portion of the upper tibial epiphysis. Furthermore, the operation is considered more complicated than necessary.

In place of this procedure, the author presents a new technique for "advancing" the patella. The patellar tendon is exposed and split longitudinally in its mid-line and strips of tendon are partially freed from the split surfaces. The patella is then pulled down by a wire, running through it horizontally and anchored to the tibia below the tuberosity. The relaxed patellar tendon is then plicated and reinforced with the freed tendinous strips.—*I. William Nachlas, M.D., Baltimore, Maryland.*

TUBERCULOSIS OF BONES AND JOINTS. N. S. Narasimhan. *The Medical Practitioner*, XI, 379, 419, 1940.

From his orthopaedic clinic at Madras the author reports *in extenso* on his experience in the treatment of bone and joint tuberculosis. He points out the difficulties in early diagnosis and emphasizes the contra-indication of massage, manipulation, and passive movement. In 90 per cent. of his cases he has found previous contact of the patient with open cases of pulmonary tuberculosis, and urges the importance of avoiding such contacts as a means of prophylaxis.—*Robert M. Green, M.D., Boston, Massachusetts.*

ÜBER DIE HÄMATOGENE OSTEOMYELITIS (Hematogenous Osteomyelitis). Richard Bertelsmann. *Monatsschrift für Unfallheilkunde und Versicherungsmedizin*, XLVII, 237, 1940.

On the basis of bacteriological investigations begun in 1902, the opinion is expressed that infection may occur during infancy. A latent infection may remain unnoticed throughout the entire life of the individual or, under favorable circumstances, lead to osteomyelitis. Injury can be recognized only as a predisposing factor in osteomyelitis, not as a cause, except under extraordinary conditions. Bacteriological examination of the blood is very essential for early diagnosis, for early treatment, and for differentiation between severe and mild forms of infection. General prophylactic measures, especially dietetic treatment, would be expected to reduce the number of osteomyelitic infections.—*R. J. Dittrich, M.D., Fort Scott, Kansas.*

VERLAUF UND BEHANDLUNG DER QUERFORTSATZBRÜCHE DER LENDENWIRBELSÄULE. (Course and Treatment of Fractures of the Transverse Processes of the Lumbar Spine.) F. A. Ostermann. *Monatsschrift für Unfallheilkunde und Versicherungsmedizin*, XLVIII, 1, Jan. 1941.

The author relates a personal experience. In 1915 he sustained an injury to the

lower spine, which resulted in severe pain for a period of ten days. Without any extensive investigation in diagnosis and with no treatment, the incident was forgotten after the symptoms subsided. About twenty years later, following the onset of severe pain on exertion, a roentgenographic examination revealed fracture of the transverse processes of the upper three lumbar segments on the right side. Since this discovery, the author has treated fractures of this type principally by withholding from the patient any information regarding the exact nature of the injury. Other therapeutic measures are immaterial. — *R. J. Dittrich, M.D., Fort Scott, Kansas.*

LESIONS ABOUT SHOULDER JOINT. A. Steindler. *Northwest Medicine*, XL, 3, Jan. 1941.

The author discusses in detail the various signs, symptoms, and pathological findings in subacromial bursitis, together with other conditions simulating bursitis. Frequent conditions are rupture of the supraspinatus tendon, and calcified deposits in frayed tendons and pathological bursae. The long head of the biceps is frequently a sufferer from tears and calcium deposits, which are often seen bilaterally.

The treatment is conservative, excepting in rare cases, as, for example, the "frozen shoulder" with severe adhesions and chronic thickening and "nictitating folds", with marked crepitus and calcium deposits. Torn tendons also require operation if they do not repair spontaneously. A summary of sixteen cases is given. — *Charles Lyle Hawk, M.D., Los Angeles, California.*

COMPENSATORY GROWTH OF LONG TUBULAR BONES FOLLOWING FRACTURES IN CHILDREN AND ITS CAUSE. I. S. Vengerovskiy. *Novy Khirurgichesky Arkhiv*, XLV, 310, 1940.

Of 1637 fractures of long bones in children up to twelve years of age, 678 were reexamined from several months to eight years after the fracture. The incidence of restoration of normal configuration was previously reported. In the present article a study of the restoration of length was made. It was found that the active compensatory growth of a shortened bone takes place during the whole period of growth of the child, but is most intense in the first two to three years after fracture. The rate of compensatory growth evidently does not depend on the amount of shortening, and at times results in overgrowth of the bone in length.

A brief recapitulation of the existing explanations of growth of fractured bones in length is given. Multiple observations of successive roentgenograms and experimental histopathological inquiries by the author convinced him that a great part of growth in length takes place at the fracture site and is interstitial in character. He believes that, although the regular bone growth plays a certain rôle, the part played by the increase in interstitial bone is most important.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

ON THE SIGNIFICANCE OF EARLY FUNCTION IN BUNNELL'S TENOPLASTY. G. F. Nikolaev. *Novy Khirurgichesky Arkhiv*, XLV, 327, 1940.

The problem of immediate, early, and late motion after Bunnell's tenoplasty is considered. The author's references include the findings and recommendations of American and other surgeons and also special studies made by Russian investigators. Examples are cited which show good function after a long period of immobilization, made necessary by the accidental paralysis of the forearm from the use of a tourniquet. Other cases are reported in which motion started early after operation not infrequently produced separation of transplanted tendons. The author reports a series of experiments on rabbits, which included operative procedures according to Bunnell's method; early mobilization produced by controlled electric stimulation in one group, and by immobilization in a second group; and parallel histological analysis of the operative sites at various time intervals in both groups. The results of the experiments proved that with early active motion the tendon suture may be inadequate, that motion in the early postoperative

stage is a disturbing factor in tendon regeneration, and that such early motion has no specific advantage in the prevention of adhesions. The author concludes that initial immobilization with subsequent guarded motion of the operated finger is the best procedure.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

UNCERTAINTIES IN THE PRINCIPLES OF OPERATIVE TREATMENT OF ACUTE HEMATOGENOUS OSTEOMYELITIS. V. P. Vosnesenskiy. *Novy Khirurgichesky Arkhiv,* XLVI, 22, 1940.

On the basis of observation of 839 cases of osteomyelitis in children, the author tries to find guiding principles as to the best method of treatment. There were forty cases of the fulminating type with a mortality of 87 per cent., for the treatment of which the author does not find any answer. All the other types he divides into two groups: (1) those with a rapid formation of one or several localized sequestra and, (2) those with immediate diffuse osteonecrosis without definite demarcation. In the first group, waiting and conservative sequestrotomies are recommended, but in the second, the use of conservative tactics is decidedly contra-indicated. The author finds that best results in the second group may be obtained by an "early secondary" subperiosteal resection of the involved bone. He calls it "early secondary" because it is preceded by an emergency single incision of the subperiosteal abscess. As soon after the incision as the primary acute stage is passed, and the roentgenogram shows the character of the process (a period of about three to four weeks), an extensive subperiosteal resection is performed. This treatment shortens the period of hospitalization and hastens regeneration of bone.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

GALEAZZI FRACTURE. S. A. Stepin. *Novy Khirurgichesky Arkhiv,* XLVI, 195, 1940.

The fracture of Galeazzi is located in the distal part of the forearm and consists of a fracture of the diaphysis of the radius about eight centimeters cephaled to the wrist joint and a dislocation of the ulnar head. Galeazzi fractures are considered rare. The mechanism is explained by the presence of the following factors during injury: change in length of the radius, interference with the parallel disposition of the bones of the forearm, interference with the synchronous motion of the radio-ulnar joints at the elbow and wrist, and interference with the normal leverage curves of the radius. The fracture is similar to the Monteggia fracture which is located at the proximal end of the forearm and consists of a dislocation of the radial head and a fracture of the ulna in its upper third. Both fractures are frequently accompanied by nerve lesions, the Galeazzi type involving the ulnar nerve at the ulnar head, the Monteggia type, the posterior interosseous branch of the radial nerve winding around the head and neck of the radius.

The treatment in fresh cases is closed reduction, or if unsuccessful, open fixation. In old unreduced dislocations of the ulnar head, various operative procedures are described, among which the author cites a restoration of the triangular ligament of the wrist, resection of the head of the radius, and two cases of Milch sling operation. However, in the presence of malunion of the radius or nerve involvement, the problem remains very complicated.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

L'HIPPOCRATISME DIGITAL UNILATERAL ET SA VALEUR DANS LES ANÉVRISMES DE L'ARTÈRE SOUSCLAVIÈRE ET DU TRONC BRACHIO-CÉPHALIQUE (Unilateral Hippocratic Fingers). M. Mariano, R. Castex, et Egidio S. Mazzei. *La Presse Médicale,* XLVIII, 931, 1940.

Classically, hippocratic fingers have been described as occurring in chronic diseases of the respiratory tract, in congenital cardiac conditions, in biliary cirrhosis, in chronic suppurations, etc. This type of drum-stick fingers is to be differentiated from the hypertrophic pulmonary osteo-arthropathy with roentgenographic evidence of bone changes.

Hippocratic fingers usually appear symmetrically on both sides. A case is presented

in which unilateral drum-stick fingers were found. The literature of similar cases is reviewed. When hippocratic fingers occur unilaterally, they are a symptom of aneurysm of the subclavian artery or of the trunk from which the subclavian arises. This sign is not pathognomonic of the condition, since it is found, according to Poland, in three out of 121 cases of aneurysm. In the typical case, no osteo-arthropathy is found. Some authors attribute the drum-stick formation to compression of the subclavian vein.—*Henry Milch, M.D., New York, N. Y.*

Sur les arthropathies mutilantes symétrique des extrémités inférieures et leurs rapports avec la syringomyélie (Symmetrical Mutilating Arthropathies of the Lower Extremities and Their Relationship to Syringomyelia). Ludo van Bogaert. *La Presse Médicale*, XLVIII, 1026, 1940.

The author reports a case which was characterized roentgenographically by fusion of tbe tarsus, and by an unusual symmetrical destruction of the metatarsal heads and osteolysis of the metatarsophalangeal joints. Clinically there appeared to be some loss of temperature perception in the big toes. Despite repeated negative tests for lues, the condition had been considered as a syphilitic arthropathy.

This diagnosis did not seem justified, and the author undertook a study of the family of the affected individual. Two other brothers were found to be suffering from mal perforant and other "structural disharmonies".

The author believes this condition is identical with the familial plantar mal perforant described by Nelaton in 1852. He is of the opinion that it really represents the atypical lumbar syringomyelia in which the neurotrophic manifestations are predominant.—*Henry Milch, M.D., New York, N. Y.*

Diagnostic précoce de la tuberculose du genou chez l'adulte jeune, ses difficultés, les éléments les plus fidèles du diagnostic (Early Diagnosis of Tuberculous Gonitis in the Young Adult). R. Dubau et F. Bolot. *La Presse Médicale*, XLVIII, 1031, 1940.

Attention is called to the fact that early diagnosis of tuberculosis of the knee is impossible in a large percentage of cases. The sedimentation rate, the tuberculin test, etc., are not pathognomonic. The regional lymph glands are positive only when the diagnosis is clear on the basis of clinical observation. Even the roentgenogram of the joint itself is not entirely dependable.

In a strictly formal sense, positive diagnosis depends on the isolation of the tubercle bacillus, either from the fluid or from the synovial membrane. Under suitable precautions, synovial biopsy can be carried out without serious danger. In lieu of these positive diagnostic procedures, the authors suggest that a roentgenogram of the soft tissues by a soft-ray technique is far more instructive than the roentgenogram of the skeletal parts. Especially in the lateral view, the roentgenogram clearly reveals the evidence of a thickening of the synovial membrane. Characteristically, the anterior and the posterior portions of the synovial membrane appear as separate thickened layers, and are united above by a downward directed concavity. Between the quadriceps tendon and the anterior layer of the synovial membrane, a small triangular shadow with base on the upper pole of the patella, is to be seen. Between the posterior layer and the shaft of the femur, another triangle, base up, is to be seen.

This appearance is believed to be typical of tuberculosis and does not occur in other inflammatory or traumatic lesions.—*Henry Milch, M.D., New York, N. Y.*

Solitary Myeloma of Bone. A Review of the Roentgenologic Features, with a Report of Four Additional Cases. L. W. Paul and E. A. Pohle. *Radiology*, XXXV, 651, 1940.

This article reviews the literature of the subject and reports four new cases. The lesion is rare, and is believed to be a true neoplasm, related to malignant lymphoma and a

variant only of multiple myeloma of the plasma-cell type. Myeloma seems to occur in varying degrees of malignancy, with generalization taking place early in some and late, or never, in others. It occurs most often in the fifth decade, involving usually the spine, pelvis, humerus, or femur. In its roentgenographic aspects it takes two main forms. One resembles a giant-cell tumor. The other is mainly osteolytic, but expansion of the bone may be present. The trabeculated, multicystic form tends to be more benign. Pathological fracture is frequent. The osteolytic type commonly involves the spine and may cross the cartilage from one body to another. Histologically, the plasma-cell type predominates.

It must be differentiated from giant-cell tumor, localized fibrocystic disease, metastatic malignancy, osteogenic sarcoma, and Ewing's tumor. The diagnosis must rest on biopsy.

The treatment is by surgery, or radiation, or perhaps best by their combination. Permanent cure is not often obtained, but palliation and prolongation of life are usually obtainable.—*Edward N. Reed, M.D., Santa Monica, California.*

MULTIPLE MYELOMA. Lyell C. Kinney. *Radiology*, XXXV, 667, 1940.

These are malignant osteolytic tumors arising from cells in the red bone marrow. By the time they are large enough to give roentgenographic findings, they are generally multiple in the involved bones, and usually occur in several different bones. Most of them are of the plasma-cell type. They are probably independent lesions, and not metastases. They may metastasize to the liver, spleen, and lymph nodes, but have not been found in the lungs. There are no characteristic symptoms, but pain is usually present, particularly after the frequently occurring pathological fractures.

Bence-Jones protein is present in the urine of from 50 to 65 per cent. of myeloma cases, but is not characteristic. The absence of Bence-Jones bodies is not significant, because they occur only intermittently in the early stages, and are absent in 30 to 50 per cent. of cases.

The bones most frequently involved are the spine, ribs, skull, and pelvis. Characteristic findings are small, multiple, clean-cut areas of bone destruction, with the appearance of having been punched out of otherwise normal bone. The lesion is purely osteolytic and does not produce bone reaction or sclerosis. There may be extensive destruction of vertebral bodies presenting no roentgenographic evidence until the cortex is involved. The ribs present diffuse mottling and demineralization, with frequent spontaneous fracture and at times complete destruction of a portion.

The osteolytic type of metastatic carcinoma closely simulates multiple myeloma and roentgenographic differentiation may be impossible. The reactions of osteitis and sclerosis frequently seen in and around metastatic lesions are never found in myeloma.

Biopsy is indicated if there is any question of multiple myeloma, and is frequently the only means of reaching an early accurate diagnosis.

The author reports four cases.—*Edward N. Reed, M.D., Santa Monica, California.*

THE GROOVED DEFECT OF THE HUMERAL HEAD. A FREQUENTLY UNRECOGNIZED COMPLICATION OF DISLOCATIONS OF THE SHOULDER JOINT. Harold A. Hill and Maurice D. Sachs. *Radiology*, XXXV, 690, 1940.

Studies of humeral heads which had been excised because of recurrent dislocation, before the advent of more conservative treatment for this condition, revealed the presence of a so-called "typical defect". This was located posterior and medial to the greater tuberosity on the posterolateral aspect of the articular surface of the humeral head. It is a wedge-shaped groove, averaging two and one-half centimeters in length, one and one-half centimeters in width, and three-quarters of a centimeter in depth. It is not usually demonstrable in roentgenograms made in the routine positions, but is readily brought out by a projection made with the humerus rotated strongly inward, which throws the

posterolateral border of the head into profile; and by a tangential view, obtained by placing the film on the top of the shoulder, with the tube lateral to and below the elbow, which brings out the width of the groove. These views show a flattening of the articular surface, or, in larger defects, an indentation or groove on a level with the greater tuberosity; and a sharp, dense line running downward from the top of the head parallel to the axis of the shaft. This "line of condensation" is the result of compression of the spongy bone previously occupying the space of the defect. Cystic changes, with borders of increased density, are often present in the posterolateral portion of the head, just beneath the articular surface.

The defect is undoubtedly the result of a compression fracture, the anterior rim of the glenoid being forced into the weak posterolateral portion of the head as it impinges in the position of anterior dislocation.

It is believed to occur in more than two-thirds of anterior dislocations of the shoulder. It is so frequently found in habitual dislocation that it is described as the "typical defect"; it may be an etiological factor in recurrence, and may lead to unsatisfactory results in operations for relief.

Eight cases are reported and illustrated.—*Edward N. Reed, M.D., Santa Monica, California.*

Agenesia sacro-coccigea (anchipodia) [Sacrococcygeal Agenesis]. Bruno Valentin. *Revista Brasileira de Orthopedia e Traumatologia,* I, 415, 1940.

In this article Dr. Valentin reports two cases of this condition, in one of which the sacrum was entirely absent; in the other a rudimentary sacrum was present. A historical summary of this unusual congenital abnormality shows that in its complete form it is seldom compatible with life. Cases of "pelvis dyspygica" described by obstetricians during the middle of the past century are of clinical interest because of difficulty in parturition. The subject remained little understood until 1924 when French research workers established the theory of a syndrome due to the numerical reduction of the sacrococcygeal vertebrae. Since then the number of reported cases has increased rapidly. Feller and Sternberg were able to show from the embryological and pathological angles that this congenital defect belongs to the same class as the so-called sirenoids which are classified as median malformations of the posterior part of the body. To this group belong atresia ani and the formation of cloacae. These authors have helped to unify this entire group of congenital defects from the mildest, showing only a partial lack of the coccyx, to the most extreme type of monster.—*Leo Mayer, M.D., New York, N. Y.*

A Parathyreóidectomia na molestia de Engel-Recklinghausen. Apresentação de tres observações. (Three Cases of Recklinghausen's Disease, Treated by Parathyroidectomy.) S. Hermeto Junior. *Revista Brasileira de Orthopedia e Traumatologia,* II, 69, 1940.

The author emphasizes the interesting opinions of Erdheim, Maresch, Mandl, and Lievre. He explains the characteristics of Engel-Recklinghausen's disease as a syndrome of hyperparathyroidism, and describes his three cases. The first patient presented a generalized form of the parathyroid osteosis, and the value for blood-calcium was found to be twenty-two milligrams per 100 cubic centimeters of serum; the second patient was a woman with a unilateral form involving specially the left limb; and the third was a young man who had two pathological fractures. Unilateral parathyroidectomy was performed on all patients. In no patient has any adenoma been found, though a bilateral exploration was always made in an attempt to find it. Reoperation was performed on the first patient eight months after the first intervention, and a noticeable improvement has taken place.

Healing of the pathological fractures was observed in the third case and the young

man returned to work. Reoperation was performed in the second patient, but without improvement.—*Prof. F. E. Godoy-Moreira, São Paulo, Brazil.*

THE CLINICAL ASPECT OF GOUT. Terray. *Rheumatism*, II, 31, 1940.

An acute attack of gout usually appears about midnight or in the early morning. It is due to a precipitation into the affected joint of uric-acid crystals. Too little attention has been given to the sources of uric acid, and to the causes which produce precipitation at certain times.

Normally uric acid is broken down by catabolism into either carbon dioxide or oxalic acid. In gout the uric acid is deposited, without decomposition, in the tissues. By experimental work it has been shown that uricaemia is due to a disturbance of the renal-hepatic function. If a normal dog is injected with uric acid and urates, one sees these substances disappear in the tissues and appear in large quantities in the urine. If, by an Eck's fistula, the liver is thrown entirely out of the circulation, no such decomposition occurs. The true rôle of the kidney is that of elimination of the urea and urates received from the blood, whereas the hepatic function aids in the decomposition of the uric acid.

Rational therapy, therefore, must be based upon a stimulation of the renal-hepatic function, since through it is obtained the fundamental lysis of the uric acid.—*Harold M. Childress, M.D., Charleston, South Carolina.*

THE PRESCRIPTION OF MASSAGE AND WHAT THIS IMPLIES. James Mennell. *Rheumatism*, II, 52, 1940.

Massage and other forms of physical therapy are often prescribed by physicians who are totally ignorant of the exact benefits to be expected from this form of therapy. The registered masseur is at a disadvantage as he must follow instructions. The ideal method is for the physician and the masseur to collaborate on the patient's condition and thereby obtain not only more accurate diagnoses, but also markedly improved end results.

"Omnibus" diagnoses, such as tennis-elbow, lumbago, sciatica, or neuritis, are utterly useless. In such cases it is for the masseur to determine exactly the points of pain, the limitations of motion, etc., and to convey his findings to the physician. By this method an exact diagnosis may be made. For instance, fibrotic deposits are fertile sources of low-back pain. Their precise locations should be determined before the usual treatment of novocain injections and deep massage are instituted. In brachialgia the causative factor may be a malalignment of joint structures in shoulder, elbow, wrist, or fingers. This factor must be definitely localized and then, as a rule, treated by manipulation.

The author discusses at length massage, joint manipulations, and electrical treatments. Each has its place in the treatment of affected muscles and allied structures, but none should be used except by one well trained in physical medicine.—*Harold M. Childress, M.D., Charleston, South Carolina.*

MUSCLE PATHOLOGY IN ANTERIOR POLIOMYELITIS. ITS RELATION TO FUNCTION. Herbert E. Hipps. *Southern Medical Journal*, XXXIV, 135, Feb. 1941.

Through a grant from the National Foundation for Infantile Paralysis, an intensive study of the gross and microscopic pathology of poliomyelitic muscles has been made. During operations for paralytic conditions, incisions were enlarged to expose the entire muscle. Photographs, sketches, and notes were made. The muscle was tested by mechanical stimulation for its ability to contract, and its elasticity and degree of tension were noted. Microscopic sections were taken from various parts of the involved muscles. This article is well illustrated and several new operative procedures are suggested. Fifty per cent. of the patients operated upon showed an appreciable gain in the strength of the muscles.

This paper gives much food for thought.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

THE IMPORTANCE OF PRIMARY CARE IN THE TREATMENT OF COMPOUND FRACTURES. H. Winnett Orr. *Southern Medical Journal,* XXXIV, 315, Mar. 1941.

Every fracture should be reduced immediately. Then it should be properly immobilized. To prevent gas gangrene it is necessary to have an open wound, with good drainage and access of air to all parts of the wound. Many modifications of the Orr method have been proposed and tried out. None have given any better results than the original method. Chemotherapy has not been proved to be of any additional value, although the sulfur drugs have been used quite extensively in connection with the Orr treatment.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

CAR WINDOW ELBOWS. Howard B. Shorbe. *Southern Medical Journal,* XXXIV, 372, Apr. 1941.

Thirty-two cases of this injury are reviewed, twenty-four of which were compound fractures. Nerve involvement was common. The types of treatment used were: closed manipulation, skeletal traction, open reduction, excision, and later bone grafts. Osteomyelitis developed in eleven patients; gas gangrene developed in two, one of whom died; and three patients had amputations.

Final results were excellent in four cases (of which two had no fracture); good with useful range of motion and useful hand in five; fair with limited motion in elbow and weakness in nine; and poor with stiff elbows, nerve involvement, and slightly useful hand in four. Eight patients had an entirely useless extremity. Those receiving efficient early treatment gave the best results. After débridement, sulfanilamide was put in the wound, and the wound closed as much as possible. Reduction of fracture and skeletal traction usually proved the best method. Extensive comminution of lower end of humerus required removal of fragments and reshaping end of bone in some instances; in others the joint was excised. The best treatment is prophylactic.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

RESULTS OF ABDOMINAL STABILIZATIONS. George O. Eaton. *Southern Medical Journal,* XXXIV, 443, Apr. 1941.

This article reports results obtained by the Lowman abdominal stabilization operations for infantile paralysis. Twenty-four of these operations were done at the Children's Hospital School in Baltimore. Twenty-five per cent. showed an increase in muscle power; 15 per cent. showed no change; and 60 per cent. showed a decrease in muscle power under the fascia. The fascial reinforcement bands which have been transplanted for an average of five years were considered too taut in four cases and too weak in two cases. Their effect on scoliosis and kyphosis is discussed. Marked improvement in gait was noted in 50 per cent. of cases; the remaining 50 per cent. showed no change. Fifty per cent. also showed increased stability when sitting. Seventy-two per cent. believed they had been benefited by the operations. No patient felt that he was worse.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

ETHYL CHLORIDE SPRAY FOR SPRAINED ANKLES. Lewis Cozen and Benjamin S. Hollombe. *Surgery,* VIII, 468, 1940.

The authors describe a technique in which ethyl chloride spray is applied, usually in the area of the sinus tarsi because this is usually the most definite tender area, until the skin of the area is white. The patient is allowed to walk without support at once. If pain persists, strapping is indicated. The authors believe the mechanism of the relief obtained is on a basis of the "break up" in the vasomotor paralysis, which the authors believe causes the greatest portion of the pain and swelling.—*F. E. Thornton, M.D., Iowa City, Iowa.*

Pathologic Study of Hypertrophic Arthritis of the Hip. Malcolm H. Sawyer and Ralph K. Ghormley. *Surgery*, IX, 381, March 1941.

Nineteen specimens of hypertrophic arthritis of the hip were studied and the pathological changes described.

The authors concluded that the initial degenerative changes appear in the cartilage and are characterized by fibrillation, pitting, degeneration of the cartilage cells, and increased calcification of the deeper matrix. The marginal cartilage proliferates and shows few of the signs characteristic of degeneration. As the cartilage disintegrates and is worn away, the bone is exposed and becomes eburnated with thickening of the subchondral plate and the subjacent trabeculae by means of intramembranous ossification. The subchondral plate may or may not be thickened. The trabeculae are almost never increased in size in those areas that are still protected by cartilage, and most formation of new bone in these areas is of the endochondral type. The normal marrow is replaced by fat or loose fibrous tissue which, in some instances, dedifferentiates into osteoid tissue. The synovial membrane is invaded by fibrous tissue with markedly increased vascularity. Little evidence was found to support the hypothesis that arteriosclerosis is an etiological factor of osteo-arthritis. Finally, no collections of lymphocytes were found, which are characteristic of the infectious types of arthritis.—*Edward L. Compere, M.D., Chicago, Illinois.*

The Treatment of Tumors of the Shoulder Region by Interscapulothoracic Amputation. J. E. Strode and E. A. Fennel. *Surgery*, IX, 394, March, 1941.

The authors conclude that the indication for interscapulothoracic amputation is most often "a relatively benign radio-resistant tumor that cannot be widely enough excised locally, due to nearness to structures important to the arm, to prevent local recurrences; in other words, tumors that are locally malignant due to their anatomical location and not from their morphologic composition".

Two cases are reported in detail: one of a carcinoma which recurred first, after local excision, and again, after removal of the tumor mass and the scapula. Radium was used repeatedly, but unsuccessfully. Three years after the initial diagnosis, the arm, including the clavicle, was removed. Fifteen years after this last operation, the patient was alive and there were no recurrences.

The second case was that of a male, aged sixty-two years, with a fibrosarcoma which arose midway between the clavicle and the spine of the scapula. Local excisions and the use of radium were in each instance followed by recurrences. Interscapulothoracic amputation was performed March 7, 1939, and after two years there are no metastases or local recurrences of this tumor.—*Edward L. Compere, M.D., Chicago, Illinois.*

The Pathological Physiology of Joints. H. Kelikian. *Surgery, Gynecology and Obstetrics.* LXXI, 416, 1940.

The article includes a short historical note and a description of the origin and classification of joints. The components of the joints, which with the exception of nerve and nucleus pulposus arise from mesoderm, are discussed under their respective headings.

The histology and nutrition of hyaline cartilage, which is essential for the maintenance of the joint space and the gliding movements, are described. It has no nerves, lymphatics, or blood vessels, and plays a passive rôle in disease. It is affected secondarily by disease of its surrounding tissues, but primarily only by trauma. To live, hyaline cartilage needs healthy cartilage on the apposed surface. Changes characteristic of degenerative arthritis are caused by continued use of a damaged joint, and not by immobilization.

The articular ends of bones are composed of a cancellous interior and a thin coating of compact bone, with vascular connective tissue present only in the former. Bone

necrosis is caused by shutting off the blood supply, by exudative proteolytic ferments, and by activated osteoclasts, and may cause articular breakdown. The virulence of the invading organism, exudate, and mechanical contact and pressure within the joint modify the development of bony ankylosis. Functional adaptation is often seen in articular ends.

The joint capsule, consisting of an outer fibrous and an inner synovial layer, binds the bones together. The histology and function of the synovial membrane are excellently described. The internal stratum is like the articular cartilage structurally, functionally, and pathologically, while the external layer is analogous to the cancellous spaces of the bone ends. New growths may form in the synovial membrane.

The synovial fluid may be an exudate or transudate. It is alkaline in reaction and contains mucin, albumin, fat, and inorganic salts. It lubricates, protects against acid metabolites, and nourishes the articular cartilage. In disease it changes in composition, reaction, and amount.

The accessory structures—namely the fibrocartilages, ligaments, muscles, tendons, and bursae—are described anatomically, and their injuries and diseases are discussed.

The circulatory relations are described and show the very close relationship between blood plasma and synovial fluid.

The summary and correlation of the writer are excellent as are the numerous illustrations of the pathology described in the text. The content is so comprehensive that no review can do it justice.—*Richard McGorney, M.D., Santa Barbara, California.*

THE SUPERIORITY OF NEOARSPHENAMINE AND SULFATHIAZOL IN THE THERAPY OF STAPHYLOCOCCUS AUREUS INFECTIONS IN MARROW CULTURES. Edwin E. Osgood, Julia Joski, and Inez E. Brownlee. *Surgery, Gynecology and Obstetrics,* LXXI, 445, 1940.

The authors made an extensive study of the effect of sulfanilamide, sulfapyridine, sulfathiazol, sulfamethylthiazol, and neoarsphenamine on staphylococcus infection in marrow cultures. In marrow cultures neoarsphenamine in concentrations of 1:150,000 to 1:200,000 was most effective. Concentrations of 1:10,000 sulfathiazol and sulfamethylthiazol were of value, but seldom produced complete sterility. Sulfapyridine was only slightly effective, and sulfanilamide was practically ineffective. Concentrations of neoarsphenamine above 1:150,000 were toxic to marrow cells, and concentrations above 1:70,000 killed all cells.

The authors' studies suggest that administration of neoarsphenamine in intermittent courses of repeated small doses, together with sulfathiazol in doses sufficient to give a blood concentration of 1:10,000, is worthy of controlled clinical investigation in serious staphylococcus aureus infections.—*F. E. Thornton, M.D., Iowa City, Iowa.*

HAMMER-TOE: A NEW PROCEDURE FOR ITS CORRECTION. Seth Selig. *Surgery, Gynecology and Obstetrics,* LXXII, 101, Jan. 1941.

The writer describes a method for cure of hammer-toe by use of a Kirschner wire placed longitudinally through the three phalanges. Previous methods are enumerated, but not recommended for reasons given, chiefly that of postoperative immobilization.

Through a medial longitudinal or transverse incision, the proximal interphalangeal joint is exposed, cartilage removed, wedge taken if necessary for alignment and a 35/1000 Kirschner wire passed with a hand chuck longitudinally through the phalanges from the tip into the wound. The toe is then lined up axially and the wire driven to the base of the first phalanx. The joint surfaces must be flush. Special pliers are of assistance. The distal end of the wire is bent to a right angle to prevent wandering. Wire position should be checked by roentgenography. The patient is discharged the same day, resuming activity in cut-out shoes.

The operation has been done on twenty toes with bony union in all properly carried out. The article is well illustrated by line drawings and roentgenograms.—*Richard McGovney, M.D., Santa Barbara, California.*

Las Fracturas Diafisarias del Femur en el Niño (Fractures of the Diaphysis of the Femur in Children). P. S. Toledo and S. Sanchen. *Vida Nueva,* XLVI, 1, 1940.

A monograph presenting an analysis of 105 cases of fractures in children, illustrated by many photographs and roentgenograms. The conclusion of the study can be briefly summarized as follows: Treatment of these fractures should be considered emergencies. The best method of treatment is overhead traction in children under seven years of age, adhesive plaster traction for children above this age unless it is inadequate. If it is inadequate, skeletal traction is necessary. It is noted that skeletal traction at times produces lengthening of the extremity. Maintenance of the normal axis in fractures is more important than approximation of fragments. Poor anatomical or roentgenographic appearance is very often accompanied by excellent functional results. Open reduction is rarely indicated in recent fractures. The prognosis is good, if the traction method is used in the presence of proper indication and carried out meticulously under constant observation.—*Emanuel B. Kaplan, New York, N. Y.*

Bedrohliches Azetonerbrechen nach orthopädischen Eingriffen (Injurious Acetone Vomiting After Orthopaedic Operations). Karl Sell. *Zeitschrift für Orthopaedie und ihre Grenzgebiete,* LXX, 21, 1939.

The author discusses the very sudden appearance and the stormy course of this complication, its etiology, and treatment. The author emphasizes it particularly in sympatheticotonic individuals, and warns of the dangers, especially in such cases as the shelving operation of the hip in which the psychic element is greatly accentuated. The urine should be examined for acetone before the operation. The patient should not fast the day before the operation, but should be given sugar, fruit juices, and dextrose in large amounts, and ample amounts of vitamins C and B-1. Inhalation anaesthesia is to be given in conjunction with rectal anaesthesia of avertin. With all this precaution the author has not had any cases of acidosis with severe symptoms for a long time.—*A. Steindler, M.D., Iowa City, Iowa.*

Die Diätbehandlung der rheumatischen Erkrankungen (Dietary Treatment of Rheumatism). W. Heupke. *Zeitschrift für Rheumaforschung,* III, 357, 1940.

Rheumatic diseases are frequently looked upon as allergic manifestations. Rossle and Klinge believe that rheumatic nodules are always allergic. If this is true, dietary regulation should be helpful. Our therapeutic approach in rheumatic diseases cannot be direct. We must attempt to elevate the resistance of the body and improve its ability to overcome the disease. For this, physical therapy with massage and baths is helpful, working through the superficial tissues. But the entire body economy must be influenced. As evidence of metabolic errors in rheumatic diseases, we have at times an elevated uric acid, a disturbed calcium exchange, and a faulty water balance. In England and America the Pemberton diet has been helpful. With the Roh diet long continued, and given in conjunction with physiotherapy, many chronic patients improve. This diet (percentages and calories not given) is poor in sodium chloride, rich in potassium, calcium, and magnesium. The protein content is decreased; and it is low in calories, but rich in vitamins. Where the appetite is poor and the patient does not wish to eat much, better progress will be observed by giving a salt-free diet or a vegetarian regimen than by giving the patient what he wants. No special diet will fit every patient and the diet must be modified for individual requirements.—*John G. Kuhns, M.D., Boston, Massachusetts.*

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ASEPTIC NECROSIS OF THE FEMORAL HEAD FOLLOWING TRAUMATIC DISLOCATION OF THE HIP

A REPORT OF NINE CASES *

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The recovery of a normal range of motion and freedom from pain, after the reduction of a traumatic dislocation of the hip and a short period of cast or traction immobilization, is generally interpreted as evidence of a complete recovery. In such instances, the patient is then permitted to bear full weight on the limb and to return to his occupation with the understanding that he is cured. This encouraging prognosis is not a safe one, for many of these individuals experience a recurrence of pain and progressive disability of the hip after months or, exceptionally, years of normal activity and unchanged roentgenograms. This reappearance of symptoms after an early period of apparent recovery is now known to be due to aseptic necrosis of the head of the femur, which had resulted from a disruption of a major portion of its blood supply at the time of the dislocation.

Forty-two cases of aseptic necrosis of the femoral head after traumatic dislocations of the hip are recorded as such in the literature. Thirty-five were in adults (Table I) and seven in children. The author wishes to add nine additional cases, and in particular to emphasize the importance of early diagnosis in order that the devitalized head may be adequately protected from weight-bearing during its revascularization and replacement by new bone.

The incidence of this complication in dislocation of the hip cannot be definitely stated, for statistics of end results are still not available on large series of cases. The only such report is that of Pfab who found two

* This paper is based on the material, first presented before the Chicago Surgical Society in April 1940, and forming a scientific exhibit at the Annual Meeting of The American Academy of Orthopaedic Surgeons held in New Orleans, January 1941.

instances of avascular necrosis in a follow-up study of twenty-four cases, or 8.3 per cent.

ETIOLOGY

The blood supply of the head of the femur in the adult is derived from the nutrient branches of the anterior and posterior circumflex femoral arteries which enter the epiphysis after passing through the capsule on the neck, and from the arteries of the round ligament. The vessels coming by way of the capsule are generally regarded as the more important, although Chandler and Kreuscher, Wolcott, Nordenson, and others have shown by anatomical studies that the arteries of the round ligament, passing into the head, are present in the majority of hips of all ages. There is some lack of evidence as to exactly which of the above vessels are injured when the head becomes necrotic. The round ligament is always torn when the femur is forcibly displaced out of the acetabulum, and probably in fractures of the floor with central displacement of the head. This may or may not give rise to necrosis, depending on the extent of the vessels from the round ligament to the head, and their collateral circulation with the arteries entering by way of the neck. It is also possible that the tear of the capsule may injure the vessels of the neck to a greater or lesser degree. In favor of the theory that the tear of the round ligament vessels causes the necrosis, is the known fact that the head may survive in case of complete fracture of the neck of the femur, proving that in such instances there is important blood supply by way of the ligamentum teres. On the other hand, when recognizable necrosis develops after dislocation, it is usually the entire head and some of the adjacent neck which is affected, and this favors the view that vessels of the neck may also have been injured. Further observations and especially pathological studies will be necessary in order to clarify this point.

PATHOLOGY

The histological alterations in the head, when it undergoes avascular necrosis and replacement following dislocation of the hip, appear to be similar to those seen, and confirmed by pathological examination, in necrotic heads after fractures of the neck of the femur followed by bony union. Axhausen, Phemister[24], and others have described in detail the pathological changes in such fractures which may be summarized as follows:

The entire head, including cortex, trabeculae, and marrow, becomes necrotic, with the exception of the articular cartilage which may survive in some cases. As the blood supply becomes re-established through union, the cancellous spaces of the head are progressively invaded from the neck, and to some extent from the round ligament, by a highly vascularized connective tissue. This invasion is followed by absorption of the dead bone and marrow, with simultaneous replacement by living bone and marrow through the process of creeping substitution. In the areas

TABLE I

ANALYSIS OF ADULT CASES RECORDED IN THE LITERATURE

Case	Author	Year	Age	Dislocation	Fracture of Acetabulum	Type of Reduction	Pain-Free Period	Interval between Dislocation and Diagnosis of Aseptic Necrosis	Results
1	Müller	1924	18	?	?	Closed	?	?	Florid Perthes' disease after 4 years
2	Bergmann	1931	52	Obturator	?	Closed	?	After many years	Wedge-shaped sequestrum without collapse of head. Good function
3	Dyes	1932	23	Obturator	None	Closed	2 years	2 years	Painful hip
4	Chandler and Kreuscher	1932	14	Central	Floor	Closed	6 months	?	Collapsed head and pain after 10 years
5	Giuliani	1933	39	Iliac	None	Closed	?	?	Deforming arthritis after 6 years
6	Stewart	1933	21	Iliac	None	Closed	Pain persisted	1 year	Collapsed head and pain after 16½ months
7	Gerber	1933	17	?	?	Closed	?	1 year	Painful deformed hip
8	Gerber		23	?	?	Closed after 17 days	?	1 year	Spontaneous ankylosis
9	Phemister	1934	14	Iliac	Posterior rim	Closed	Pain persisted	11 months	Replacement after 1 year and 7 months. Good function after 2 years and 4 months
10	Waldenström	1936	23	?	None	Closed	6 months	?	Collapsed head and pain after 2 years; arthroplasty

TABLE I—*Continued*

Case	Author	Year	Age	Dislocation	Fracture of Acetabulum	Type of Reduction	Pain-Free Period	Interval between Dislocation and Diagnosis of Aseptic Necrosis	Results
11	Bunne	1936	44	Obturator	None	Closed after 4 months	?	10 months	Not stated
12	Küster-Zesas		16	?	?	Closed	?	1 year	Not stated
13	Blumensaat	1936	33	Obturator	None	Closed	5 weeks	6 months	Collapsed head and pain after 3 years and 11 months
14	Blumensaat		55	Obturator	None	Closed	3 months	8 months	Collapsed head and pain after 2 years
15	Blumensaat		60	Iliac	Posterior rim	Closed	3 months	3 months	Collapsed head and pain after 2 years
16	Massart et Vidal	1936	27	Iliac	None	Closed	1 year and 6 months	3 years	Painful, deformed hip
17	Kaijser	1936	26	Iliac	None	Closed	2 years	?	Painful, collapsed head after 6 years
18	Del Campo y Prat	1937	46	Ischiatic	None	Closed	1 year	1 year and 8 months	Painful, deformed hip
19	Funsten, Kinser, and Frankel	1938	48	Iliac	Posterior rim	Closed, traction 6 weeks	?	?	Painful hip after 6 years
20	Funsten, Kinser, and Frankel		46	Iliac	Rim	Traction 10 weeks	?	?	Fair, after 6 months

21	Funsten, Kinser, and Frankel		46	Iliac	None	?	?	1 year and 3 months	Resection of head
22	Funsten, Kinser, and Frankel		23	Iliac	Rim	?	?	8 months	Shelf operation. Head partly re-dislocated after 8 months
23	Pfab	1938	19	Iliac	None	Closed	?	?	Painful, deformed hip
24	Pfab		57	Iliac	Rim	Closed	?	?	Painful hip
25	Potts and Obletz	1939	34	Iliac	None	Closed	3 years	?	Painful, deformed hip; arthrodesis
26	Potts and Obletz		31	?	None	Closed	5 years	?	Painful hip; arthrodesis
27	Potts and Obletz		19	?	None	Closed	3 years	?	Painful hip; arthrodesis
28	Potts and Obletz		20	?	None	Closed	3 years	?	Arthroplasty
29	Potts and Obletz		30	?	None	Closed	2 years	?	Arthroplasty
30	Kleinberg	1939	15	Iliac	None	Closed	8 months	?	Painful, deformed hip
31	Kleinberg		19	?	None	Closed	7 months	?	Painful hip
32	Birch-Hirschfeld	1939	12	Iliac	None	Closed	Several months	3 years and 5½ months	Pain, collapsed head after 4 years and 9 months
33	Phemister	1940	61	Iliac	Posterior rim	Closed	6 months	9 months	Pain, deformed head
34	Watson-Jones	1940	?	?	?	?	?	?	Deformed hip
35	Walker	1940	23	Anterior	None	Closed	?	?	Collapsed head after 2 years

of transformed bone, the trabeculae are irregularly arranged and less dense than is the adjacent unreplaced dead bone, thus making it possible to distinguish such regions in the roentgenograms. All osseous elements in circumscribed areas may be completely replaced by fibrous tissue, producing cystlike zones of reduced density in the roentgenogram.

When the zone of transformation approaches the peripheral portions of the epiphysis, the bony articular cortex also becomes absorbed along with the subcortical bone, but subsequently may be irregularly replaced. Articular cartilage obtains a portion of its nutrition from the synovial fluid, and its chances of survival are enhanced if there is rapid revascularization of the underlying dead bone. If cartilage necrosis occurs, there is overgrowth by fibrous tissue or fibrocartilage.

An osteo-arthritis is frequently superimposed upon the necrotic head, and this condition is characterized pathologically by a villous synovitis, acetabular sclerosis, marginal osteophytes, and occasionally the formation of loose bodies in the joint.

Necrosis following dislocation has been diagnosed mainly on the clinical course and roentgenographic appearance of the hip. It must be emphasized that while death of the femoral head occurs shortly after the dislocation, it cannot usually be detected by roentgenograms at the end of six weeks when the patient is ready to resume walking. This is because the early roentgenographic diagnosis of a dead femoral head is dependent upon marked disuse atrophy of the adjacent living bone of the shaft and pelvis. Since the necrotic head without blood supply cannot participate in this decalcification, it will retain its original density and cast a shadow of greater intensity in the roentgenograms than will the surrounding living bone. Ordinarily, three to four months are required for sufficient atrophy to occur before this contrast between the living and dead bone is distinguishable in roentgenograms. As walking is usually resumed within six weeks of traumatic dislocation, there is insufficient time for density differences to develop between the dead head and the living shaft, and the complication temporarily goes unrecognized. The patient resumes full activity and continues to bear weight on the devitalized head until late changes, due to collapse or degenerative arthritis, cause the return of hip pain. This is usually the first clinical indication that epiphyseal necrosis has followed the dislocation. Roentgenograms will now show late evidence of necrosis, in the form of progressive replacement of avascular dense bone by less dense, irregular, living bone, alterations in the shape of the head following collapse or fragmentation, or signs of a deforming arthritis.

The following case reports will illustrate many of these features. The first patient demonstrates the typical clinical course and roentgenographic findings when the necrotic head is detected before it has undergone collapse or fragmentation, and when it is adequately protected from weight-bearing during its transformation.

Case 1. W. H., male, aged *twenty-four*, *sustained a posterior dislocation of the left* hip in an automobile accident (Fig. 1-A). Immediate reduction was successful and nor-

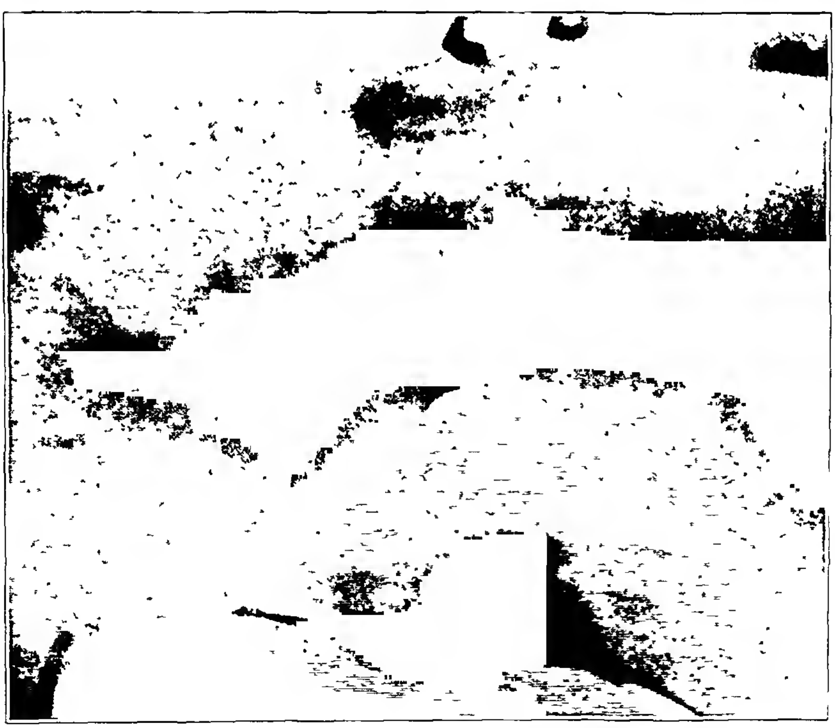

Fig. 1-A

Roentgenogram showing recent posterior dislocation of the left hip without fracture of the head or acetabulum.

Fig. 1-B

Roentgenogram after thirteen months showed slight flattening of superior surface of the femoral head (*a*). Note the absence of density difference between the dead head and the living shaft.

FIG. 1-C

Roentgenogram after twenty-seven months revealed partial replacement across base, and inferior, medial, and lateral portions of the head. The wedge-shaped, proximal necrotic zone (*a*) remained unvascularized.

mal function was recovered after three weeks of plaster immobilization. Then, after nine months of unlimited use of the hip, pain returned, first after active exercise and subsequently after prolonged standing, as was necessary in his work as a press feeder. A roentgenogram of the pelvis at that time showed a small triangular shadow of bone in the soft tissues proximal to the greater trochanter, and minimal flattening of the head in its weight-bearing region. The pain gradually became worse and was moderately severe when the patient was first examined in the Clinic thirteen months after the dislocation, and four months after the reappearance of symptoms. The gait was normal, but motion was limited in all directions by muscle spasm, and pain could be elicited on extreme flexion.

Roentgenograms (Fig. 1-B) showed slight but definite flattening of the head of the left femur in its proximal portion and slight diminution in the articular cartilage space. Its density corresponded to that of the surrounding bone, which did not show atrophy of disuse, and the entire shadow of the bony articular cortex was unchanged.

In view of the previous dislocation and the presence of flattening at the top of the epiphysis, a diagnosis of aseptic necrosis of the head of the femur was made. Weight-bearing on this extremity was avoided for the following thirty-one months by means of crutches, in an endeavor to prevent further collapse of the fragile dead head while it was being transformed.

Roentgenograms (Fig. 1-C), taken twenty-seven months after the dislocation, showed replacement across the base and inferior mesial portion of the head, as indicated by its diminished and irregular density, which corresponded more or less to the then

Fig. 1-D

Roentgenogram after thirty-three months showed further reorganization of the head. Dead area at the top of the epiphysis was smaller in size and more irregular in density.

Fig. 1-E

Roentgenogram forty-three months following dislocation and thirty-four months after return of pain revealed final restoration of the head. Note the *absence* of *fragmentation* of the epiphysis or evidence of arthritis.

Fig. 2-A

Roentgenogram showing fracture of the anterior margin of the acetabulum with posterior dislocation of the hip.

Fig. 2-B

Roentgenogram four weeks after injury showed incomplete reduction of the femur, but its head was smooth in outline and of normal density.

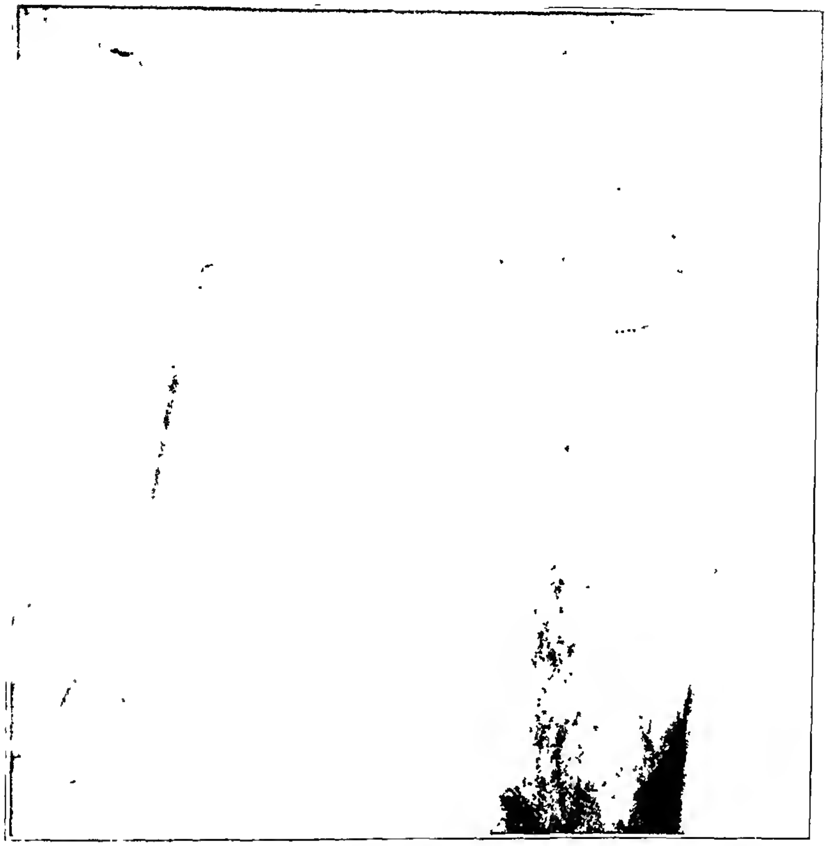

Fig. 2-C

Roentgenogram after eighteen months revealed advanced replacement of the inferior medial portion of the head while the proximal two thirds was necrotic and uninvaded.

atrophic living bone of the left femoral shaft and ilium. The proximal half of the epiphysis was dead, as its density remained unchanged and was similar to that of the non-atrophic right hip.

Roentgenograms (Fig. 1-D), taken thirty-three months after the injury, revealed absorption of the articular cortex over the mesial and lateral portions of the epiphysis, indicating that the centrifugally directed process of revascularization had reached the periphery of the head in those regions. The articular cortex remaining over the triangular shadow of devitalized bone in the weight-bearing region, on the other hand, was unchanged in density and outline.

Roentgenograms (Fig. 1-E), forty-three months following the dislocation and thirty-four months after the return of pain, showed final replacement of the head with the probable exception of a small linear area across the superior surface. The cartilage space was well maintained and roentgenographic evidence of a degenerative arthritis was limited to marginal lipping.

The patient is now bearing partial weight on the extremity without pain, while hip motion is restricted except for flexion and extension.

It is to be noted that adequate protection of the epiphysis from weight-bearing by means of crutches during its reorganization eliminated pain and prevented further compression or fragmentation of the head. The present anatomical and functional result is good.

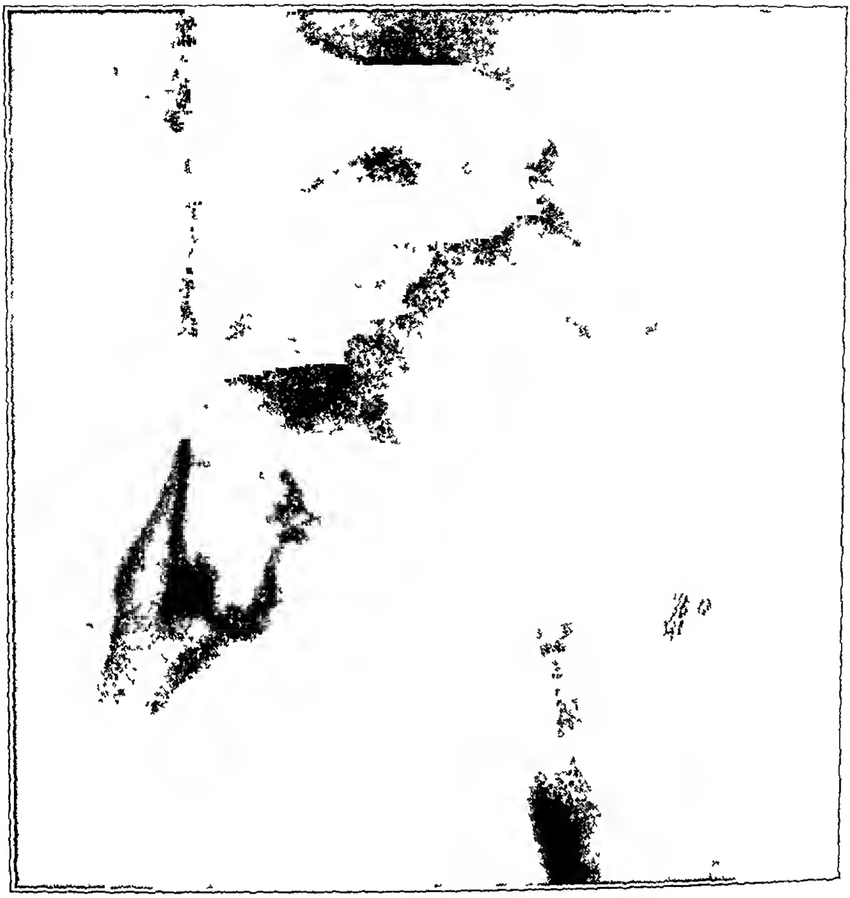

FIG. 2-D

Roentgenogram six and one-half years after dislocation showed marked collapse of the head in its weight-bearing portion, and extensive deforming arthritis.

When the patient is not forewarned of the possibility of late pain in the hip, and continues to bear weight on the extremity for prolonged periods after the return of symptoms, the head may undergo marked collapse with depression of the articular surface, particularly at the points of maximum pressure. These changes are at times irreparable and result from compression of dead trabeculae, or fractures through necrotic old or fragile new bone. Fractures are prone to occur through devitalized bone just proximal to the zone of transformation after a major portion of the head has been replaced and walking continues.

If such a fracture occurs, and the proximal dead fragment becomes reattached to the head, it may readily be invaded by connective tissue and replaced by new bone in a relatively short time. On the other hand, when a non-union develops between the fractured fragment and the rest of the head, the former persists as a sequestrum at the top of the epiphysis for a prolonged period. In rare instances, fibrous tissue overgrows the contacting surfaces of sequestrum and head, resulting in a pseudarthrosis as was described by Kraft in a case of Legg-Perthes disease, and by

Phemister [26] in a dead head after a fracture of the neck of the femur. Naturally, this prevents invasion of the dead fragment, and years may be required for final restoration of the head, as is illustrated by Case 4.

The next four cases demonstrate the prolonged disability and poor functional results which follow traumatic dislocations of the hip, when the necrotic head becomes greatly altered in shape, or a sequestrum forms in its weight-bearing region.

CASE 2. W. T., male, aged thirty-seven, received a dashboard dislocation of the left hip with an associated fracture of the anterior medial margin of the acetabulum (Fig. 2-A). Closed reduction was performed and the extremity maintained in extension for eight weeks. A roentgenogram (Fig. 2-B) taken four weeks after the injury showed moderate persisting upward displacement of the femur, due to inadequate reduction. The head appeared smooth in outline and of normal density. Crutches were used for two months following the period of recumbency and then a cane. Mild pain and stiffness persisted in the hip. This was increasing when the patient entered the Clinic eighteen months after the acute injury. Examination revealed marked atrophy and weakness of the thigh muscles, and his weight could not be maintained on the involved extremity.

The roentgenogram (Fig. 2-C) showed the upward displacement of the left femur with loss of cortical shadow over the acetabulum. The head appeared smaller than that of the normal right femur, and its medial third was irregular in outline. The proximal two thirds of the head was necrotic, as indicated by the persistence of its normal density, the trabecular pattern, and the shadow of the articular cortex. The medial portion and a small area on the lateral side had been partially replaced, as suggested by its spotty reduced density and the absorption of the overlying articular cortex. The linear density proximal to the head and neck represented extensive ossification in the capsule.

The presence of aseptic necrosis of the head of the femur was evident. A surgical arthrodesis was advised in view of the patient's disability and the alterations in the hip joint. He refused operation and was not seen again for five years.

During this interval he maintained less than half-time employment because of pain in the hip. Physical examination now showed further flexion and adduction deformity, and motion was restricted and painful.

Roentgenograms of the hip (Fig. 2-D) taken six and one-half years after the dislocation revealed a flattened and irregular head of the left femur with loss of substance in its weight-bearing region. Transformation of the head was completed, for it was of an irregularly reduced density corresponding to the persisting regional atrophy of the femur and ilium, and the shadow of articular cortex was entirely absent. An extensive proliferation of new bone along the posterior acetabular margin and throughout the capsule gave the head a mottled appearance on the single roentgenogram.

Operation was again refused by the patient, although the hip was exceedingly painful and functionally poor.

CASE 3. H. H., male, aged forty-three, suffered a comminuted fracture of the left ischium with posterior dislocation of the femur, when a mass of iron ore fell on his hip. Reduction was performed under a general anaesthetic and the hip immobilized for six weeks in a plaster dressing. Full functional use of the extremity soon followed and continued without pain for fifteen months. A roentgenogram (Fig. 3-A), taken five months after the accident, showed satisfactory healing of the fracture and no abnormalities in the head of the femur.

Physical examination two months after the reappearance of symptoms, during which time weight-bearing had continued, showed considerable muscle spasm about the hip, and limitation of motion in all directions. A roentgenogram disclosed a diminution in the cartilage space and marked flattening and irregularity in the outline of the head.

FIG. 3-A

Roentgenogram five months after posterior dislocation of the hip showed satisfactory healing of fractured left ischium and no abnormalities of the femoral head.

FIG. 3-B

Roentgenogram after twenty-two months showed a disc of dead bone (*a*) at top of the head, separated from hypertrophied replaced bone (*c*) by band of decreased density (*b*). Note the large exostosis at the lateral margin of the epiphysis.

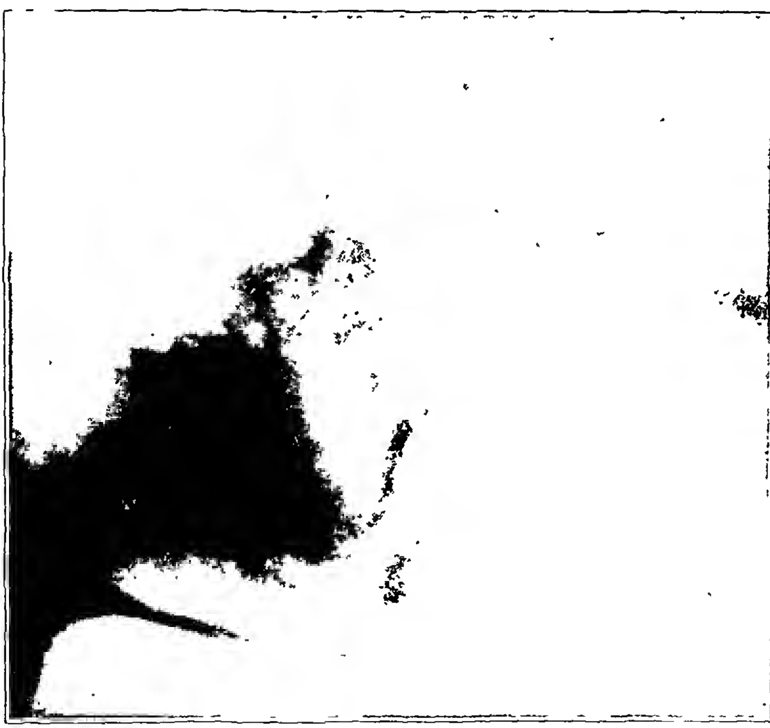

FIG. 3-C

Roentgenogram after thirty-five months revealed invasion and organization of sequestrum with loss of cartilage space.

FIG. 3-D

Roentgenogram seven years after injury showed an extensively deformed hip joint.

FIG. 4

Roentgenogram five years after return of pain and seven years after dislocation showed old sequestrum (*a*) which had been invaded and transformed, but was still separated from the remainder of the head by a zone of transformation (*b*). Note the hypertrophy of the replaced bone (*c*) across top of the epiphysis in response to the sequestrum, and over the mesial third, due to weight-bearing.

The upper half was dead, as shown by its spotty increased density, when compared to that of the lower half. The latter was undergoing transformation and its diminished density corresponded to the adjacent osteoporotic living bone. There was sclerosis of the acetabular margin, while bone formation in the capsule and along the superior margin of the neck was prominent.

The hip was protected by a non-weight-bearing caliper brace for eight months. The pain subsided and the range of motion gradually increased.

Transformation of the necrotic head was followed in roentgenograms. One, taken twenty-two months after the dislocation (Fig. 3-B), showed at the top of the head a flat irregular disc of dead bone which had become separated from the main osseous portion of the epiphysis by a band of decreased density corresponding to the zone of absorption. There had been further transformation of the inferior mesial portion of the head, as indicated by its more uniform diminished density and the loss of the overlying shadow of articular cortex. Its upper dense margin represented hypertrophy of newly formed bone, probably secondary to the presence of the sequestrum. The bony projection from the lateral portion of the head was definitely limiting abduction of the extremity.

Roentgenograms of the pelvis (Fig. 3-C), taken thirty-five months after injury, showed further reorganization of the head, including the sequestrum, while the trabecular pattern, particularly in the distal portion, was reforming.

The patient was first examined in the Clinic seven years after the dislocation. He

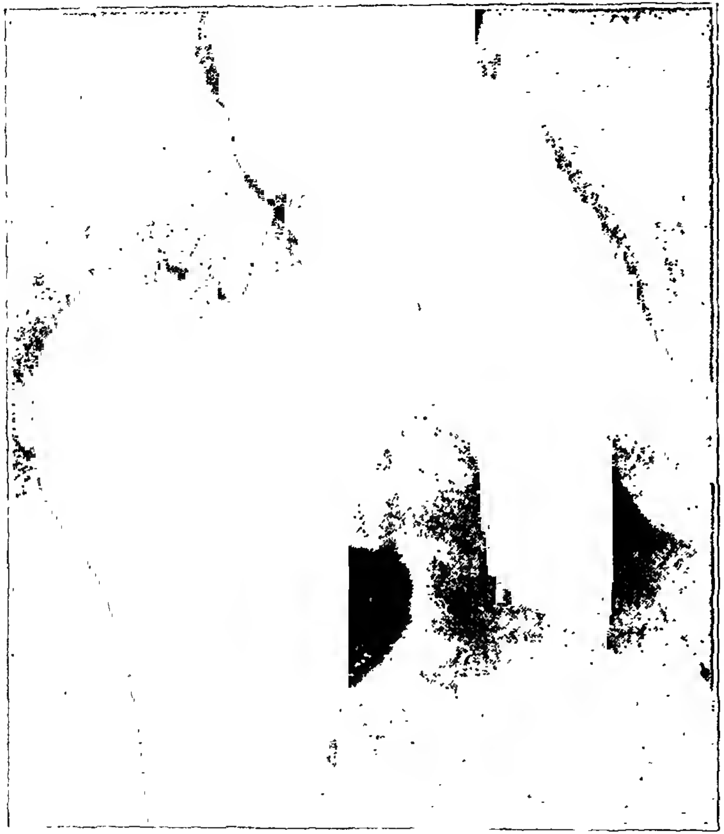

Fig. 5-A

Roentgenogram showed a recent fracture of the base of the acetabulum with central dislocation of the hip. The femoral head appeared normal in shape and density.

Fig. 5-B

Roentgenogram after three and one-half years revealed collapse of the head with sclerosis of the underlying bone and secondary arthritis.

had continued his employment as a metallurgist, and used a crutch while at work and a cane at other times. Flexion of the hip was free to 90 degrees, while abduction and adduction were negligible and painful. Stereoscopic roentgenograms (Fig. 3-D) revealed complete transformation of the head, which had undergone marked collapse with a resulting irregular, flat superior surface. The ossification within the capsule overlying the head gave it a mottled appearance on the single film. Acetabular sclerosis and marginal new-bone formation indicated a far-advanced secondary osteo-arthritis.

The patient was satisfied to continue the use of a cane or a crutch, and refused to consider arthrodesis.

Case 4. L. C., male, aged forty, sustained a traumatic dislocation of the left hip. After reduction and three weeks of immobilization in a plaster dressing, the patient enjoyed normal use of the extremity for two years. Pain then returned and increased gradually during the next five years with marked disability.

A roentgenogram (Fig. 4), taken seven years after the acute injury, showed an irregularly deformed femoral head with loss of cartilage space, secondary sclerosis of the acetabulum, and the formation of marginal osteophytes. The shadow of the entire old articular cortex was absent. A dense shadow in the weight-bearing region apparently represented a portion which had become separated from the remainder of the head as a result of a pathological fracture with subsequent invasion and transformation. Below this old sequestrum, and in response to its presence, the replaced bone had undergone hypertrophy, and its shadow was denser than that of the surrounding living bone. The marginal sclerosis over the medial third of the head, in response to weight-bearing, and the restoration of trabecular pattern in the transformed areas were striking.

Case 5. H. B., female, aged sixty-eight, sustained an injury to the right hip when she was struck by an automobile. A roentgenogram (Fig. 5-A), taken immediately, showed a fracture of the base of the acetabulum with central dislocation of the hip. The shadow of the femoral head was normal in shape and density. The extremity was elevated on pillows for six weeks with no attempt at reduction. The hip remained painful after the period of recumbency, and full activity could not be resumed.

The patient used the hip in spite of pain, and did not seek further medical aid for three years. Roentgenograms, obtained at that time, showed the site of the previous fracture to be well healed, but the deformed femoral head was slightly centrally displaced with loss of its superior articular portion and narrowing of cartilage space. Marked sclerosis had occurred along the irregular acetabular margin. The reduction in density of the greater portion of the head corresponded to that of the surrounding atrophic living bone, and there was marked thinning of its overlying cortex. The area of increased density at the region of collapse was due to hypertrophy of replaced bone in response to weight-bearing.

The patient was first admitted to the Clinic three and a half years following the dislocation. Her chief complaint was pain in the hip. Physical examination disclosed a right hip limp and extreme muscle atrophy of the thigh. Abduction, as well as adduction, was negligible and painful, while flexion was unrestricted.

Roentgenograms (Fig. 5-B) showed the hip to have changed little in appearance since the last examination. It was evident that aseptic necrosis of the head of the femur had resulted from a loss of a major portion of its blood supply at the time of the injury. Restoration of the dead head had apparently been completed, but weight-bearing during the period of reorganization had caused collapse at the point of maximum pressure. It is interesting to note that this had not occurred at the top of the head, but over the lateral surface where the full weight of the body was being borne because of the slight persisting central displacement of the femur.

Surgery was contra-indicated in view of the patient's age and general physical condition, but the hip pain was relieved by crutches. Roentgenograms taken seven months later showed no change in the appearance of the femoral head.

Fig. 6

Roentgenogram showed iliac dislocation of eighteen years' duration and healed fracture of the acetabulum. The necrotic femoral head had been transformed except for the calcified central dead portion (*a*).

The next case affords further evidence that unprotected walking on the devitalized head is responsible for the collapse and alterations in its contour. In this instance, reposition of an iliac dislocation was not accomplished and, although the patient resumed walking on the limb, the shape of the head remained unmodified. This is to be explained by the fact that the superincumbent body weight was not transmitted directly onto the head through the medium of the acetabulum. The case is of additional interest because the necrotic central portion of the head had apparently remained unreplaced, and subsequently calcification occurred similar to that described by Phemister [25] in a devitalized head following an intracapsular fracture of the femur, and by Kahlstrom, Burton, and Phemister [14] in large, aseptic, bone infarcts resulting from caisson disease.

Case 6. S. K., male, aged fifty-five, was first seen in the Orthopaedic Clinic because of pain, referable to the lumbosacral spine and left gluteal region, of six months' duration. Eighteen years previously he had been in a railroad accident and suffered multiple fractures of the pelvis and a posterior dislocation of the left hip which had not been reduced. He remained in the hospital for one year, during which time he gradually became ambulatory and was able to bear full weight on the left leg, although there was some insta-

Fig. 7-A

Roentgenogram showed posterior dislocation of the right hip and fracture of the mesial portion of the head.

Fig. 7-B

Roentgenogram twenty months after dislocation showed an irregular fragment of bone beneath the inferior medial surface of the head and neck.

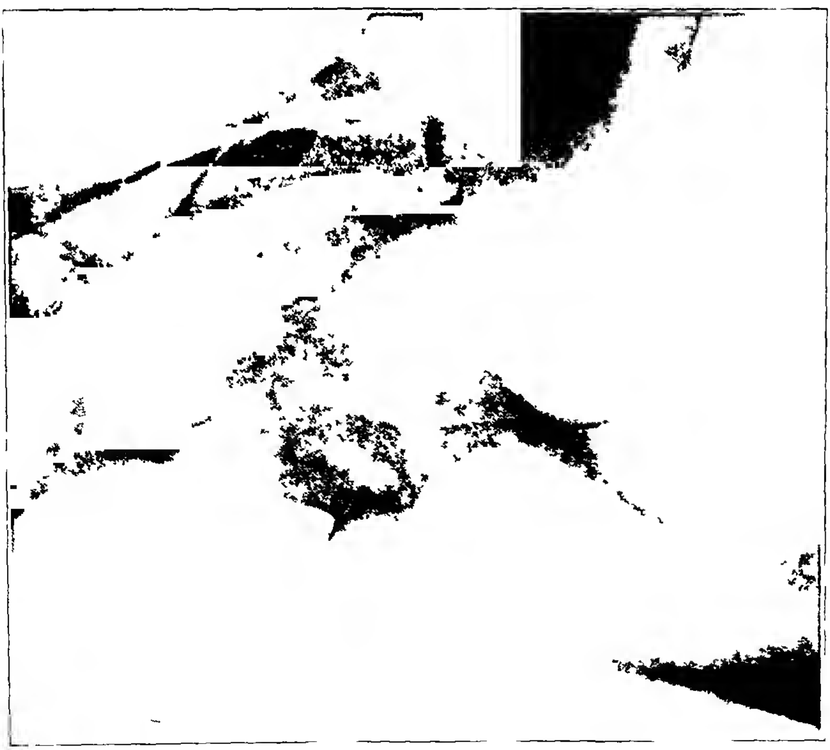

Fig. 7-C

Roentgenogram after surgical removal of bone fragments revealed no alteration in the femoral head

Fig. 7-D

Roentgenogram five years after dislocation showed irregular density of the head, diminution in cartilage space, and secondary arthritis

Fig. 8-A

Roentgenogram showing fracture of the posterior wall of the acetabulum. The femoral head is unchanged in shape and density.

ity. Physical examination on admission to the Clinic revealed a left hip limp, a mild ght lumbar scoliosis, and the left leg to be four inches shorter than the right. Motion the hip was full and painless.

Stereoscopic roentgenograms of the pelvis (Fig. 6) showed the head of the left femur to be displaced from the acetabulum and riding high on the posterior surface of the ilium. The outline of the head was smooth but indistinct, following irregular absorption of the bony articular cortex. The diminished density of the peripheral portion of the epiphysis was similar to that of the atrophic shaft of the femur, and was in marked contrast to the calcified central dead portion which produced a dense irregular shadow two by one and five-tenths centimeters on the roentgenogram. The increased density of the medial portion of the neck was not related to the central density in the head, but was due in part to the hypertrophy of the trabeculae along new lines of weight-bearing force, and in part to the superimposition of a portion of the ischium. The acetabulum was obliterated and deformed as the result of a healed fracture; and the right pubic bone was the site of two previous fractures.

The next case illustrates the reappearance of pain four and a half years after a traumatic dislocation of the hip.

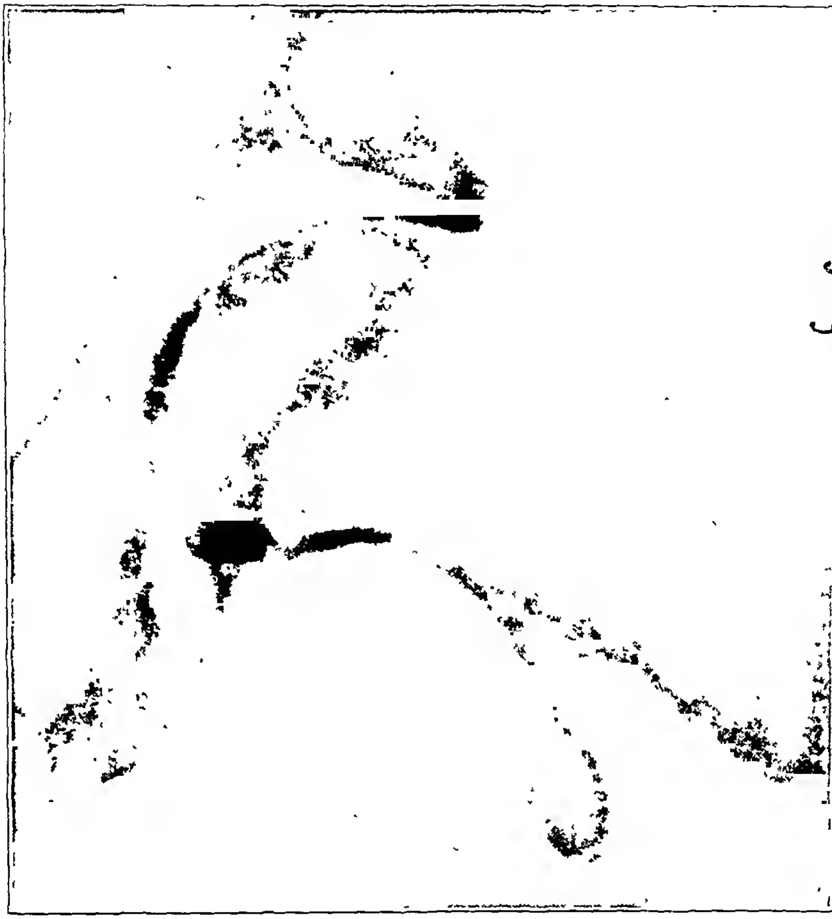

FIG. 8-B

Roentgenogram after thirty months revealed a flattened head of mottled density and far-advanced osteo-arthritis.

CASE 7. A. A., male, aged fifty, sustained an injury of the right hip when he was caught in a moving belt of a conveyor. A roentgenogram taken then revealed a posterior dislocation of the hip and a fracture of the mesial portion of the head (Fig. 7-A). The dislocation was reduced immediately, and, after sixteen weeks, the patient was able to resume his former occupation. He stated that during the next fourteen months the hip remained symptom-free, and he had unlimited use of the extremity. Pain then recurred spontaneously, and was marked when he was first seen in the Clinic twenty months after the dislocation. Roentgenograms (Fig. 7-B) then showed a shadow of bone density at the inferior border of the head and neck, which was interpreted as a chip fracture of the head. This was verified at surgery when the small osseous fragment was found loosely attached to an incompletely obliterated defect on the posteromesial surface of the head.

Roentgenograms (Fig. 7-C), taken immediately after surgery, showed only a small spicule of bone remaining beneath the inferior margin of the neck. The head appeared normal in outline while the joint space and acetabulum were unaltered.

The patient wore a non-weight-bearing caliper brace for six weeks following the operation, after which the hip was entirely painless and motion was only minimally restricted. He did not return to the Clinic again for three years. Six months previous to this, pain had returned in the hip for a second time and had prevented him from working.

Fig. 9-A

Roentgenogram obtained soon after primary injury showed an obturator dislocation of the left hip.

Fig. 9-B

Roentgenogram after fifteen months showed areas of replacement about the periphery of the head, while the remaining central dead portion was extremely dense.

Fig. 9-C

Roentgenogram after twenty-two months showed complete restitution of the osseous center, except for several linear streaks of necrotic bone.

Fig. 9-D

Roentgenogram after six years and two months revealed a flattened but smooth head with maintenance of the joint space. Note the absence of secondary arthritis.

Roentgenograms (Fig. 7-D), taken five years after the dislocation and approximately three years after the arthrotomy, showed irregular areas of increased and decreased density throughout the slightly flattened head of the femur. The articular cortex had been absorbed over the medial portion of the epiphysis where a large area of diminished density extended up to the joint surface. At the lateral margin there was a triangular shadow of apparent new-bone formation. The cartilage space was diminished in width with sclerosis of the acetabular margin. Arthrodesis was advised, but refused.

Spontaneous reduction of a subluxation of the hip occasionally occurs immediately following the acute trauma, or as the patient is being transported to the hospital. The initial roentgenograms may, therefore, appear entirely normal. However, if the displacement of the femur was of sufficient magnitude, capsular vessels, as well as vessels of the ligamentum teres, may be torn to such an extent that aseptic necrosis of the head results, and the patient experiences late pain and progressive disability of the hip. A patient of Dr. H. Gordon Heaney of Corpus Christi, Texas, appears to have presented such a sequence of events, although roentgenographic proof of the subluxation is lacking.

Case 8. L. L. W., male, aged thirty, injured the left hip in an automobile accident. Roentgenograms (Fig. 8-A), taken the day of the accident, showed a linear fracture of the posterior margin of the acetabulum, but no changes in the femoral head. Full use of the extremity followed a short period of bed rest. Then, after thirty months, pain in the hip returned and grew progressively worse as walking was continued.

Examination showed limitation of flexion and pain on rotation of the leg. Roentgenograms (Fig. 8-B) revealed a flattened head of mottled density with irregular absorption of the articular cortex, while the cartilage space was markedly diminished in width. Sclerosis of the acetabular margin and new-bone formation about the acetabulum and head indicated a far-advanced secondary arthritis.

A diagnosis of aseptic necrosis of the femoral head following a traumatic subluxation of the hip was made, and the patient was advised to use crutches. Pain and disability persisted and a vitallium-cup arthroplasty was performed.

Traumatic dislocations of the hip are occasionally encountered in young children. Seven patients whose dislocations were followed by death of the femoral head have been recorded [9, 13, 21, 28, 30, 33] as such in the literature. The roentgenographic changes during replacement of the head appear somewhat similar to those observed in Legg-Perthes disease, and the immediate end results are equally satisfactory. The osseous center undergoes necrosis with subsequent invasion and transformation.

When the femoral head in older children becomes necrotic [3, 6, 16, 24], the pathological alterations simulate those seen in adults and the results are equally poor. This appears to be true whether the primary pathological condition was a traumatic dislocation, a fracture of the neck of the femur, or a slipping of the upper femoral epiphysis.

Case 9 illustrates the changes associated with aseptic necrosis of the femoral head after traumatic dislocation of the hip in a child.

Case 9. F. F., male, aged twelve, a patient of Dr. Frank D. Dickson's, sustained an obturator dislocation of the left hip without an associated fracture of the femur or acetabulum (Fig. 9-A). The hip was immobilized in a plaster dressing following closed reduction, and the patient's recovery was complete. Fifteen months later, pain returned,

and roentgenograms (Fig. 9-B) showed a mottled appearance of the head not unlike that seen in Legg-Perthes disease. There were numerous small areas of osteoporosis about the periphery of the capital epiphysis where replacement had already occurred, while the central, unrestored, dead portion was extremely dense. The cartilage space was unchanged in width and the acetabulum appeared normal.

Further weight-bearing was prevented, and roentgenograms (Fig. 9-C), taken seven months later, showed restoration of the epiphysis except for several linear areas of dead bone persisting in the central portion. The shadow of the articular cortex was absent, and the ossification center of the head was slightly decreased in height. Apparent interference with growth at the epiphyseal plate had resulted in a shortened and broadened neck with relative upward displacement of the greater trochanter. In spite of the changes in the osseous center, the cartilage space corresponded in width to that of the right hip.

The subsequent course showed final reorganization of the bone epiphysis, and the patient's functional recovery remained good six years and two months after the injury. Roentgenograms (Fig. 9-D) then showed the head to be somewhat flattened, but relatively smooth in outline, while the joint space was well preserved, and there were no arthritic changes.

END RESULTS AND TREATMENT

Any patient who sustains a traumatic dislocation of the hip may develop late changes in it, due to aseptic necrosis of the femoral head. Of the forty-three recorded cases in older children and adults, thirty-nine have resulted in deformed and painful or ankylosed hips. In each of these instances, the head had undergone extensive collapse or fragmentation before the patient returned for medical care after the period of apparent recovery, or before the primary pathological condition was recognized. This demonstrates the importance of early diagnosis, and the necessity for adequate protection of the fragile, devitalized head during its restitution, if the prognosis in these cases is to be improved. Since the presence of a dead head cannot usually be detected soon after the initial injury, either by clinical or roentgenographic examination, the physician may approach the problem of early diagnosis in one of two ways, as follows:

Whenever possible, the extremity may be protected from weight-bearing by means of crutches for four to six months after the postreduction period of immobilization or recumbency. If the femoral head undergoes uniform atrophy of disuse and no density difference develops between it and the then osteoporotic living bone of the shaft and the ilium, as shown by roentgenograms, the patient may resume full weight-bearing with the likelihood that the head has remained alive, although roentgenographic follow-up should continue for an additional twelve months. However, if the head is thus shown to be necrotic, early protection can be provided and continued until serial roentgenograms show final revascularization and replacement by new bone.

On the other hand, if the patient insists on walking six weeks after the dislocation without the aid of crutches, roentgenographic examination of the hip must be obtained at intervals over a period of at least two years, although the extremity may appear clinically intact. When the diagnosis becomes available before much damage to the head has occurred, weight-bearing should be prevented until replacement has been completed. If,

however, the hip is already the site of a marked deforming arthritis which precludes the possibility of a satisfactory outcome, an arthrodesis appears to be indicated.

While the end results have been almost uniformly bad in adults and older children, the outcome has been gratifying in eight young children in whom a traumatic dislocation of the hip was followed by aseptic necrosis of the femoral head.

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AN IMPROVED SHELF OPERATION AT THE HIP *

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The construction of a shelf over the head of the femur may be required in several kinds of instability of the hip joint, such as:

1. Older cases of unreduced congenital dislocation of the hip.
2. Successfully reduced congenital hip dislocations, where, in later life, the upper rim of the acetabulum fails to develop sufficiently to cover the femoral head (very properly called "dysplasia of the acetabulum").
3. Congenital subluxation of the hip, "in which there is a more or less pronounced displacement of the femoral head in the acetabulum, . . . but in which part of the head still lies in the acetabulum", as described by Wiberg.
4. Plastic changes in the shape of the femoral head, such as may occur in coxa plana (Legg-Calvé-Perthes disease), or other deforming conditions.
5. Certain cases of hip instability following arthroplasty, reconstruction operation, or the acute, suppurative epiphysitis of infancy.

Nearly all of the shelf operations hitherto described have involved turning down a flap of bone from the outer table of the ilium over the femoral head, and bracing this flap by small bone grafts placed between the flap and the ilium. This method is not mechanically sound. In adults and adolescents, the flap is apt to be fractured completely at the base while being turned down, and cannot be fixed in place with sufficient solidity. In such cases, traction and protection must be continued for a long time, in order to prevent upward displacement of the shelf. Even in children, where the flap undergoes only an incomplete, greenstick fracture, the mechanical fixation is not very secure. In addition to this objection, there is difficulty in placing the shelf directly above the femoral head. The author has seen many cases and many reports of cases where the shelf has been constructed at so high a level above the head that the operation has been of no value to the patient. Notwithstanding these disadvantages, this method has been widely used in American and foreign clinics, with slight and unimportant variations in technique, and has given excellent results in many cases. In Europe it is usually called Lance's method.

The tibial-peg shelf operation described by Compere and Phemister furnishes a strong and stable shelf, on good mechanical principles, but requires the removal of bone grafts from the tibia, and does not supply a smooth surface of cortical bone.

Hallock mentions the use of a free graft of bone from the ilium, driven in immediately above the femoral head. He does not state from what portion of the ilium the graft is removed, and the author does not think his procedure is exactly like the one here described. On June 10, 1939, a

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, New Orleans, Louisiana, January 14, 1941.

short report of the author's method was read at the celebration of the Seventieth Anniversary of the founding of the Boston Children's Hospital, but the report was not published.

During the last five years, a technique has been developed which seems better and simpler than any of the other operations that have been described. It is adapted particularly to patients over ten years of age.

PLAN OF OPERATION

A square or rectangular piece of the full thickness of the wall of the ilium is excised, and is then driven into a deep slot cut with a thick osteotome directly above the head of the femur. It needs no supporting struts or bone grafts to hold it in place. Only a short period of traction in bed is required, for, as soon as the incision is healed, the patient may be allowed to get up and walk about with crutches. Only one incision is needed. The large opening left in the wall of the ilium has not caused any disturbance, probably because the periosteum of the visceral side of the ilium is left intact and is reinforced by the strong iliacus muscle.

TECHNIQUE OF OPERATION

A Smith-Petersen incision is used to expose the anterior half of the ilium and the capsule covering the head of the femur. The capsule is not opened, but it may be stripped from the wall of the ilium if there is much upward displacement of the femoral head. The head may then be pulled down as much as is practicable.

A thick osteotome is now driven horizontally into the wall of the ilium just above the head of the femur, to a depth of one-half to three-quarters of an inch or more, depending upon the thickness of the ilium at the desired level. This slot is extended forward and backward sufficiently to correspond with the size of the femoral head, and is curved slightly like a shallow acetabulum. It can be cleaned out with a small curette through its entire length and depth (Figs. 1 and 2).

An area is now selected on the upper, curved surface of the wall of the ilium, just below the crest, and a rectangle of appropriate size is marked out by four drill holes at the corners. The drill is driven through the entire thickness of the ilium, including both tables of the bone. It is easy to do this with the hand drill operated at slow speed, and one can gauge accurately the depth of the bone at the different corners. A thin-bladed, half-inch osteotome is used to cut out the graft, which in older patients is about one and a half by two inches in size. The thickness of this graft will be found to vary considerably, being thicker in the portion nearer the acetabulum. It has a slightly curved surface, which makes it fit the femoral head with some degree of accuracy.

After the edges of the graft have been smoothed and the corners rounded, the thinner edge is driven firmly into the slot with a blunt impactor or a small hammer. If the graft projects farther than is necessary, it can be trimmed with a rongeur forceps. This shelf is so strong and

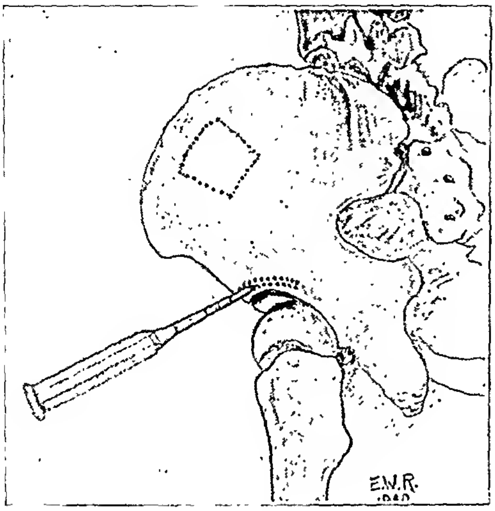

FIG. 1

Chisel cutting deep slot above femoral head.

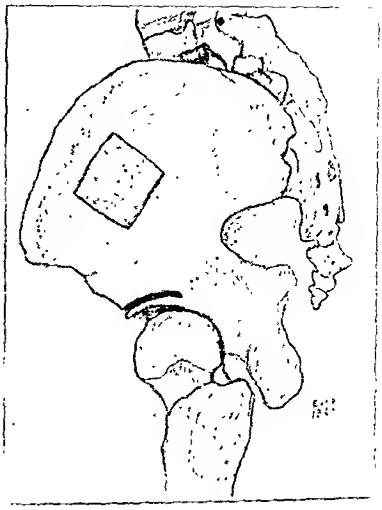

FIG. 2

Slot completed. Full-thickness graft outlined on ilium.

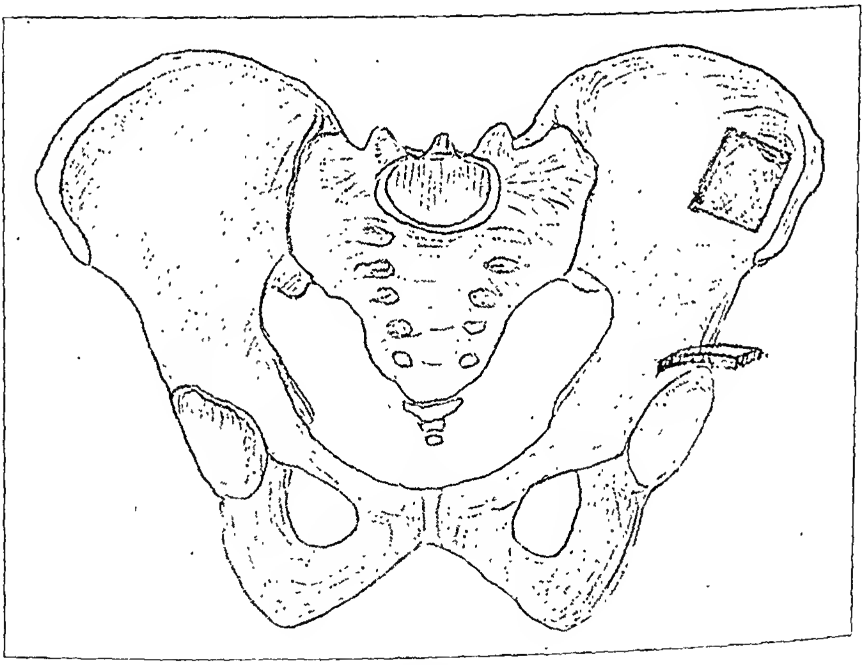

FIG. 3

Graft in place.

solid that no supplementary bone grafts are needed (Fig. 3). All bleeding is carefully checked, using Horsley's wax, if necessary, in the cut edges of the ilium. The incision is sutured in the usual manner, and a firm muslin spica bandage is applied over thick layers of sheet wadding.

The patient is put to bed with a Buck's extension of only sufficient weight to balance the muscle pull. It is not necessary to draw the femoral head away from the shelf.

Fig. 4

Case 2. B. K. November 23, 1940, two years after operation. In addition the large bone graft from the ilium, two small tibial pegs were inserted diagonally ver the corners of the graft, as it was not then known that the graft does not eed support when inserted into the ilium. The shadows of the pegs can be seen ove the graft. Patient has complete relief of symptoms.

Fig. 5-A

Case 3. A. T. May 17, 1939, condition before operation.

Fig. 5-B

Case 3. A. T. August 16, 1939, three months after operation.

Fig. 5-C

Case 3. A. T. June 2, 1941, roentgenogram shows defect in ilium unfilled. Patient has complete relief of symptoms.

Fig. 6

Roentgenogram taken June 3, 1941, of patient on whom operation described was performed on July 15, 1939, by Dr. R. O. Ritter.

Several other patients on the author's Service have been operated upon in this manner. Figure 6 shows the result in one patient.

This method is simple and mechanically sound, and can be performed in a relatively short time. The convalescence is rapid, and the results have been extremely satisfactory.

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THE SIGNIFICANCE OF PHLEBOTHROMBOSIS AND THROMBOPHLEBITIS IN ORTHOPAEDIC SURGERY *

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In a previous publication[5], attention was directed to the distinction between thrombophlebitis and phlebothrombosis. In the former the intravascular clotting is associated with, and dependent upon, inflammation of the wall of the vein, whereas in the latter there is little or no associated inflammatory process. For this reason, in phlebothrombosis the thrombus may not be firmly attached to the vessel wall and the danger of embolism is greater.

The significance of thrombophlebitis and phlebothrombosis to the orthopaedic surgeon lies in the fact that such a complication is not infrequently associated with conditions commonly observed in this field of endeavor. Thus, for example, patients with arthritis are particularly likely to develop thrombophlebitis, as are elderly patients with hip fractures. Its importance also lies in its immediate potential danger to the life of the patient, and its subsequent morbidity. For these reasons a consideration of the prophylaxis and therapeutics of this condition may be warranted.

No attempt will be made here to discuss in detail the etiology of phlebothrombosis and thrombophlebitis, as this has been reviewed previously. However, it is believed desirable to consider succinctly some of the factors which play significant rôles in the development of these conditions. These have previously been classified as: (1) predisposing and (2) precipitating. The most important of the former are constitutional diathesis, obesity, debility, systemic infection, pregnancy, trauma, operation, and circulatory disturbances. The precipitating factors are: (1) vascular changes, (2) blood changes, (3) infection, and (4) circulatory retardation.

By constitutional diathesis is meant a thrombo-embolic predisposition which is an inherited tendency, and is likely to occur in patients of the asthenic, adipose type. In a patient who has had a previous thrombosis, or who has a family history of this condition, it is highly desirable to employ prophylactic measures which will be discussed under therapy. Of the debilitating conditions, carcinoma is of particular importance, probably because of the destruction of tissue which produces changes in the blood, favoring thrombosis. Pregnancy is likely to be associated with thrombosis because of the increased intra-abdominal tension, re-

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sulting in pressure on the pelvic veins and vascular stasis in the lower extremity. Probably of all the factors, trauma is the most significant to the orthopaedic surgeon who is called upon so frequently to treat trauma of the osseous system with injury to the soft parts. The question has frequently been raised: Why is it that intravascular clotting does not occur more frequently following extensive injury to an extremity in which tissue damage, particularly to the soft parts, may be considerable? Certainly a trauma of equal severity elsewhere in the body would produce blood changes sufficient to be considered as precipitating factors in the production of thrombosis. These changes, as emphasized previously by the authors[5], are increased viscosity, hyperglobulinaemia, hyperproteinaemia, — that is, an increase in the albumin-globulin ratio — increased fibrinogen content, antitryptic power, peptidase, and calcium content, and a decreased carbon-dioxide-combining power of the plasma. In addition to these changes in the plasma, there are significant changes in the formed elements of the blood, which consist of an increase in the number of thrombocytes and an increase in their agglutination tendency. This is probably the result of the change in the albumin-globulin ratio of the plasma, tending to decrease the electrical charge of the platelets. The leukocytes are similarly increased, and also show an increased agglutination tendency. The erythrocytes, although decreased, show the same agglutination tendency, as exemplified by the rouleau formation.

Circulatory retardation has long been considered one of the most important precipitating factors. As previously emphasized[5,9], any condition which will interfere with the normal return circulation and predispose to venous stasis may act as a precipitating factor. Thus, posture, immobility, hypopnea, and increased abdominal tension may produce circulatory retardation.

In a patient with extensive trauma of an extremity associated with a fracture, in whom, after reduction has been done, immobilization is secured by means of plaster, it would seem that the conditions were ideal for the development of thrombosis, — namely, changes in the blood, which predispose to intravascular clotting, and circulatory retardation, favoring the production of a clot. For these reasons, it may at first appear difficult to explain why thromboses do not occur much more frequently in such instances. There are probably several reasons which might be given. Whereas trauma can and does occur in elderly individuals, most of the extensive injuries of the extremity occur in relatively young individuals whose vascular system is relatively unimpaired, and in whom vascular stasis is less likely to occur. It is a well-known fact, as has been previously emphasized by the authors[5,9], that intravascular clotting is more likely to occur in advancing age. Of even greater importance probably is the vasodilating effect of choline derived from the injured muscle in the extremity. This tends to offset the disadvantages of immobilization and tends to overcome vascular stasis. Of great significance also is the increased heat to the part, resulting from the retention

of the natural body heat by the plaster. Were it not for this last fact, probably many more venous thromboses would occur in such individuals. The authors [5,9] have previously directed attention to the significance of heat and consequent vasodilatation on the incidence of thrombophlebitis. Thus, for example, the incidence of thrombophlebitis is considerably lower in southern climates and during warmer months. The extremely low incidence of thrombophlebitis in this Clinic is due, in the authors' opinion, to the fact that heat tents which cover the lower portion of the body, including the lower extremities, are routinely applied postoperatively.

The clinical manifestations of venous intravascular clotting vary considerably according to the extent and site of involvement. Everything else being equal, the more proximal the location of the vein — that is, in the femoro-iliac area of the lower extremity — the more severe the clinical manifestations. Pain is almost invariably present. As venous clotting is most likely to occur in those areas in which there are the greatest number of tributaries, the popliteal vein, the veins of the calf, and the femoro-iliac veins are those most frequently involved. There is usually some fever, although the temperature elevation may not be high. A step-ladder type of temperature curve is quite common. Swelling of the extremity is an almost invariable accompaniment of deep-vein thrombosis, although it may be absent in involvement of the superficial veins. Here also the more proximal the vein involved, the greater are the extent and the degree of the swelling, — that is, the involvement is greatest in the femoro-iliac vein, where the typical phlegmasia alba dolens appears. The temperature of the involved extremity varies according to the site of involvement. In cases in which the superficial veins are involved, there is increased heat over and along the course of the involved vein, and there is usually redness, whereas in the individual with deep-vein involvement the extremity is frequently cold and white, as evidenced by the "alba" in "phlegmasia alba dolens". It is rather difficult to understand why, for so many years, physicians disregarded the apparent paradox that a patient with a definite inflammatory disease involving the venous system, as evidenced by marked pyrexia, should have an extremity which not only is not as warm as the rest of the body, but commonly is actually colder than a normal extremity. The whiteness of the extremity has been usually attributed to the stagnation of the lymph.

The diagnosis of intravascular clotting is not particularly difficult. The presence of predisposing and precipitating factors—such as antecedent trauma with tissue destruction, infection, circulatory retardation, and other factors stated above—are highly suggestive. If in addition to these factors there are such clinical manifestations as pain and tenderness over and along the course of an involved vein, associated with swelling of the involved extremity and fever, a diagnosis of thrombophlebitis is justified.

In venous thrombosis, as in other conditions, the best method of therapy is that of prophylaxis. Although one cannot control the degree of trauma in disease or in the accidental injuries, the surgeon can decrease the postoperative incidence of intravascular clotting by being as atraumatic in his operative technique and in his manipulations as is possible. In previous publications[7, 9, 10], the prophylactic therapy was discussed in detail, and the most important factors were outlined as: (1) hydration, (2) mobilization, (3) respiratory stimulation, (4) prevention of increased abdominal tension, and (5) application of heat. In this regard early post-operative mobilization of the extremities is highly desirable. In individuals in whom immobilization is necessary, the application of heat to the involved extremity is of importance. Obviously, in a patient whose extremity is immobilized in plaster, the retention of the body heat is efficacious in increasing the heat of an extremity and in producing vasodilatation. The avoidance of abdominal distention is of importance in reducing the likelihood of vascular retardation in the veins of the lower extremity. It is also important that the flow of venous blood to the heart should be favored by the use of deep-breathing exercises, as this increase in the intrathoracic negative pressure augments the return flow of blood.

Once thrombophlebitis has occurred, the most rational form of therapy is based upon an attempt to counteract vasospasm, and to produce maximum vasodilatation in the involved extremity. That vasospasm plays a prominent rôle in the development of the clinical manifestations of thrombophlebitis has been demonstrated by clinical and experimental observations[1, 3, 8]. On the basis of these observations it is believed that a vasomotor reflex is initiated in the thrombosed venous segment, causing widespread vasospasm of the vessels of the involved extremity. These vasoconstrictor impulses are transmitted by way of the sympathetic nerve fibers. This spasm in the arterioles is responsible in great measure for the decreased temperature and pallor of the involved extremity, which is so typical of a deep-vein thrombosis. It also explains the apparent paradox of a white, cold extremity in a patient who has a systemic pyrexia. The oedema, which previously has been attributed to the increased intravenous pressure resulting from obliteration of the large venous channel draining the extremity, cannot be explained on this basis, because by the prompt institution of adequate therapy the oedema will subside in a period of a few days, long before the intravascular clot has become recanalized. As previously emphasized by the authors[5, 7, 8, 9, 10], the oedema in cases of thrombophlebitis is not due primarily to the increase in the venous pressure, resulting from the plugging of the large venous channel of the extremity, but is due principally to a number of factors which are the result of the vasospastic influences arising in the thrombophlebitic segment. As a result of the marked arteriolar spasm, the blood flow through the capillaries is decreased. This causes a relative anoxia of the capillary endothelium which increases its permeabil-

ity and results in excessive exudation of intravascular fluid into the perivascular spaces. Although this explanation is adequate for the presence of increased perivascular fluid, it does not explain the persistence of the oedema. The vascular spasm, in venules as well as in arterioles, is responsible for its persistence. Because of spasm in these vessels and increased venous pressure, the pressure on the venule ends of the capillaries is increased, and this interferes with the absorption of the fluid in this area. Of particular importance in this regard, also, is the accumulation of proteins in the perivascular fluid, which further increases the oncotic pressure of tissue fluids, thus tending to hold and attract fluids into the tissue spaces. Normally, a good deal of the perivascular fluid gets back to the vascular system by way of the lymphatics. As has been shown by McMaster and Parsons [4, 11] and by Cressman and Blalock [2], movement of the lymph is dependent upon arteriolar pulsations. During the period of arteriolar spasm resulting from impulses originating in the thrombophlebitic segment, stasis of lymph occurs because the "pump", which is responsible for its movement, is not functioning normally.

Accordingly, the treatment of thrombophlebitis consists in producing vasodilatation of the involved extremity, and this can be done best by novocain block of the lumbar sympathetic ganglia, which successfully interrupts the vasoconstrictor impulses arising in the thrombophlebitic segment. In this way the vascularity in the capillary bed is increased; the relative anoxia of the capillary endothelium is prevented; and the normal permeability of the capillary endothelium is reestablished, which prevents the continuation of the excessive exudation of intravascular fluid into the perivascular spaces. Of equal importance also is the effect of the return of arteriolar pulsation on the movement of lymph. As arteriolar pulsation is the most important factor in the movement of lymph, the reestablishment of these normal pulsations will result in the removal of the excessive perivascular fluid and its return to the vascular system. This further decreases the protein content of the tissue fluid, which, in turn, diminishes its oncotic pressure, thus preventing the accumulation of perivascular fluids. Because of the relief of the spasm on the venule side of the capillary, absorption of the perivascular fluid into the venous end of the capillary is favored. In this way the rapid subsidence of oedema might be anticipated, a fact which has been established clinically.

The technique of the novocain block of the sympathetic ganglia is extremely simple, and has been adequately described in previous publications [6, 7, 8]. Briefly, it is as follows: For the lower extremities, lumbar sympathetic block is performed on the affected side, with the patient lying in the lateral recumbent position. The cutaneous sites of puncture are determined by taking a point approximately two to two and a half finger-breadths lateral to, and on a horizontal level with, the spinous processes of the first lumbar vertebra. Each needle is inserted verti-

cally until the transverse process of the vertebra is reached. The direction of the needle is then changed slightly, passing either above or below the transverse process, and the needle is introduced for an additional two to two and a half finger-breadths so that its point lies near the anterolateral surface of the body of the vertebra in the retroperitoneal space where the sympathetic chains lie. Five cubic centimeters of 1-per-cent. procaine-hydrochloride solution is injected through each needle, care being taken to determine previously that the needle is not in a vessel. In cases with involvement of the upper extremity, the anterior approach, which is a modification of the Leriche approach worked out by one of the authors (M.D.), is preferred. A point one centimeter medial to the mid-portion of the clavicle is chosen and an intracutaneous wheal of novocain is made into the skin immediately over the upper border of the clavicle. A fine lumbar puncture needle is introduced on a horizontal level with the clavicle and directed posteriorly and medially at a forty-five degree angle with the mid-line. The point of the needle, after being introduced for a distance of from six to seven centimeters, impinges against the anterolateral surface of the body of the seventh cervical vertebra or at the junction between the seventh cervical and first thoracic vertebrae, where the stellate ganglion lies. After ascertaining by aspiration that the needle is not in a vessel, ten cubic centimeters of 1-per-cent. novocain is introduced. A satisfactory injection is determined by the presence of Horner's syndrome, anhydrosis, and an increase in warmth in the extremity on the injected side. Sympathetic ganglion block is done daily until the patient is fever-free, because it is believed that, as long as the fever persits, vasospastic impulses can originate in the thrombophlebitic segment.

Forty-one cases of venous intravascular clotting have been treated in this way.* One of the most dramatic results of the therapy is the prompt relief of pain as soon as the procaine block has been completed. Within twenty to thirty minutes after the block, a patient who has previously had considerable pain is completely relieved. Of the forty-one patients, thirty-five (85.4 per cent.) were permanently relieved by the first block, and six (14.6 per cent.) required a second block to relieve them permanently of their pain. There is a rapid subsidence of fever, the temperature dropping 1 to 3 degrees within twelve hours. Of the forty-one patients, twenty-five (61 per cent.) were fever-free in forty-eight hours or less, nine (22 per cent.) were fever-free in from three to five days, five (12.2 per cent.) were fever-free in from seven to eight days, and only two had fever persisting longer than eight days. Of the forty-one patients, only forty had oedema, because one occurred in a patient who had had a previous amputation. The prompt relief of oedema is as dramatic as the subsidence of the fever. Of the forty patients with oedema, twenty (50 per cent.) had a normal-sized extremity within four

* Since this article was written, seventy-one cases have been treated by this method. An analysis of these results has been published.[11]

days or less after the first block. In twelve (30 per cent.) the oedema subsided in from five to eight days, in six (15 per cent.) in from nine to ten days, and in two the oedema lasted as long as the eleventh or twelfth day. These figures, and the duration of the patient's stay in the hospital, are particularly significant when one considers that all of these patients had typical cases of phlegmasia alba dolens in which one would expect a long convalescence, a persistence of pyrexia for weeks, oedema for weeks or months or possibly for the rest of their lives, and the probability of the development of other postphlebitic sequelae. Not only are the discomforting symptoms and dangers of the condition obviated, but the prompt institution of adequate therapy in this condition is of great economic importance, as illustrated by the duration of the hospital stay in thirty-nine of the forty-one patients who were observed. Two of the patients were seen at home, so that they cannot be included in the hospital series. Twenty-six (66.7 per eent.) were diseharged from the hospital on the fourth to the eighth day, nine (23 per cent.) from the tenth to the twelfth days, and only four (10.3 per cent.) remained in the hospital more than twelve days.

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A SIMPLE METHOD OF AMBULATORY TREATMENT OF FRACTURES OF THE CLAVICLE

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Greenstick fractures of the clavicle require very little attention. Wharton Hood's method is the simplest and gives satisfactory results.

In fractures of the clavicle with marked displacement, various methods of putting up the fracture have been described, each having its good points. Those that are simple are not effective, and those that are effective require a mechanic's help to construct a splint to suit the individual case. The principle of putting up fractures of the clavicle is well known, but maintenance of the fragments in the corrected position is difficult. due to respiratory movements and the difficulty of keeping the shoulders braced back without immobilizing the spine. Hawley tried to solve the problem by his T-shaped splint, but this requires constant attention and adjustment. Böhler's method of reducing a fracture of the clavicle is very simple, but it requires a mechanical appliance adjusted to fit each individual. In South India, working in a place where a mechanic's help is difficult to obtain, the author adopted the following simple technique, using plaster of Paris.

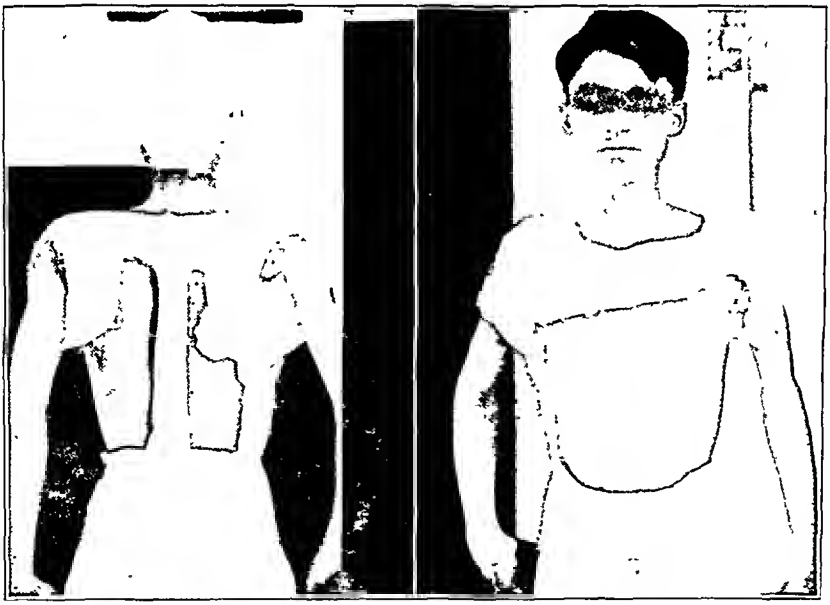

FIG. 1-A FIG. 1-B

Clinical photographs illustrating the method of using plaster bandages in correcting fractures of the clavicle.

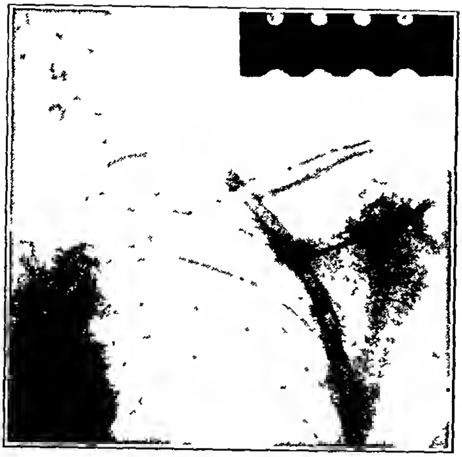

FIG. 2-A

Roentgenogram showing displacement of fracture of the clavicle.

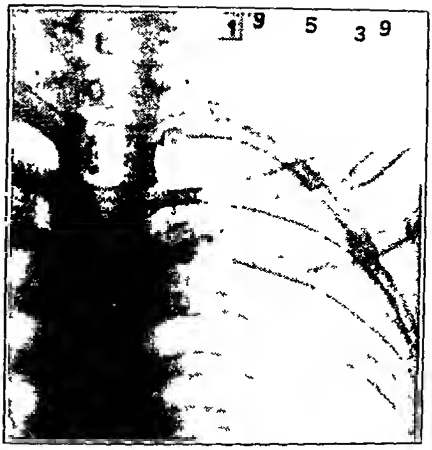

FIG. 2-B

Roentgenogram showing the result two years after reduction.

Two axillary roller pads of jute fiber covered with cotton, of the size required, are put under the armpits with the shoulders braced back by an assistant. Adhesive-plaster strips are applied to the area over the fracture of the clavicle, so as to give support and to prevent effusion. First, a pelvic support is made by plaster-of-Paris bandages rolled around the waist and molded over the crest of the ilium, and this support is covered with sponge rubber. Second, a padded plaster-of-Paris strip, four layers thick, four inches wide, and long enough to cover the front of the chest below the neck, is applied and molded over the front of the shoulders. A similar padded strip, four layers thick, four inches wide, and of the required length, is applied on the back and molded over the dorsum of the shoulders. (See Figures 1-A and 1-B.) Third, a plaster-of-Paris strip is made and rolled into a smooth rod, flat at the ends; this is fixed to the plaster-of-Paris strip on the back above and to the pelvic support below. Fourth, a flat, thick, smooth strip of plaster of Paris is molded to the injured side of the chest, the axillary pad, and the pelvic support. When this sets, it acts as an axillary crutch, lifting up the shoulder and maintaining it in that position. A roller plaster-of-Paris bandage is then passed around the axillary pads and the front and back of the chest over the strips in a figure of eight, and molded gently without causing undue pressure. Similarly, the lower end of the rod is firmly fixed to the pelvic support by a roller plaster-of-Paris bandage. When the plaster of Paris sets, the shoulders are automatically braced back and held in that position by the rod and strips in front and back of the shoulders, preventing bending or sagging; the axillary crutch supports the shoulder in the corrected position. This is a very simple and efficient method of reducing fractures of the clavicle by plaster-of-Paris splints and is very useful in tropical countries.

Plaster jackets in the ambulatory treatment of fractures of the clavicle, as described by Young, have been tried with success in two cases

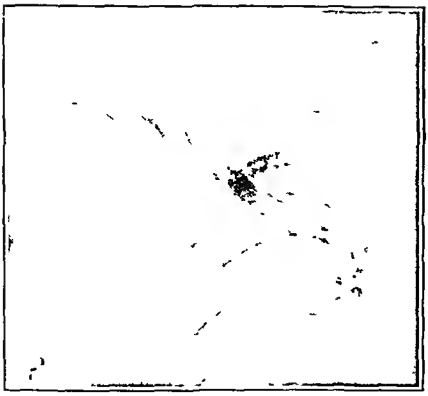

FIG. 3-A

Roentgenogram showing displacement of the fracture of the clavicle.

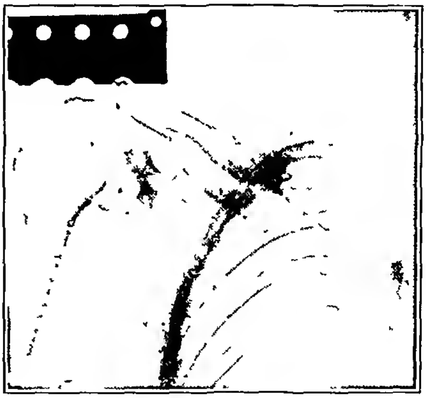

FIG. 3-B

Roentgenogram showing union of the fragments two years after the accident.

where a cosmetic result was desired. The principle is very good, but in tropical countries a plaster jacket causes great discomfort to the patient. The method just described has been modified by using a T-shaped splint with a posterior strip and axillary support (Figs. 4-A and 4-B). This method is quicker, and the results have been very encouraging.

The principle of the clavicle splint of Böhler has also been employed by the author. The axillary crutch is made by molding soft jute fibers into a pad covered with layers of plaster-of-Paris bandage; the portion of the splint which comes in contact with the side of the chest is made smoother

FIG. 4-A FIG. 4-B

Modified method of application of plaster-of-Paris splint for fracture of clavicle.

by using not more than two or three layers of plaster-of-Paris bandage and by inserting a layer of lint of the same size with the rough side next to the plaster of Paris when the plaster is still wet, so that the fluffy side is next to the skin. On the outer side, the pad is made a little thicker to strengthen it and to prevent it from cracking. The top of the pad is made smooth and round, and over it a sponge-rubber pad is fixed. The lower end of the pad is flattened, as it has to be fixed to the pelvic support made of plaster-of-Paris bandage. This method of application of plaster of Paris has given very satisfactory results. It is useful in treating older people whose shoulders should be kept free for movement. Usually strips of adhesive plaster are stuck on the area over the two fracture ends to give support and to prevent further effusion.

These methods are described to show how plaster of Paris can be put to a useful purpose for manufacturing splints when a mechanic's help is difficult to obtain.

The author wishes to express his gratitude to Dr. P. Kesavaswamy, roentgenologist, for the roentgenograms included in this paper.

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ACROMIOCLAVICULAR DISLOCATION

A New Operative Treatment *

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The majority of patients with disloeations and subluxations of the acromioclavicular joint recover with conservative treatment. In only a small percentage of the eases, which may be termed ehronic, is there permanent impairment through pain and loss of function. The operation to be described is for the ehronic type of lesion.

The function of the clavicle, other than for the attachment and origin of certain muscles, is purely one of a strut or buttress to hold the tip of the shoulder out from the body. It does not have any weight-bearing function. Excellent function of the upper extremity is consistent with an absence of the clavicle. This is seen in congenital deformities, or after the entire bone has been removed later in life, and in other cases in which the continuity of the clavicle has been disturbed, as in non-union of fractures, in complete dislocation at the acromioclavicular joint, and in partial excision of the bone. This point is illustrated by two paticnts seen by the writer: One was a nurse, in whom the entire clavicle was excised, and one was a man in whom the distal end of the bone had lost all contact with the acromion as a result of dislocation. In both cases there was complete and full function of the shoulder, without pain. The acromioclavicular articulation is a simple type of arthrodial joint without any special features. Within its capsule is found, not infrequently, a meniscus or articular disc, usually occupying the upper part of the joint. A superior and an inferior ligament strengthen the capsule. The clavicle, pivoting at the sternal end, is maintained in relation to the scapula by the coracoclavicular ligament, which has an anterior portion (trapezoid ligament) and a posterior portion (conoid ligament) to limit rotation of the claviele.

Watkins,[1] in his study of acromioelavicular lesions, observed that, when the point of the shoulder is depressed, the clavicle eomes to rest upon the first rib, and at the same time oeeurs a forward rotation of the elaviele about its sternal end as a center. If the foree persists, either the clavicle fractures or the eoraeoclavicular ligament ruptures with an assoeiated luxation of the aeromioclavicular joint. It was upon these findings that he based his operation for the repair of the ehronieally dislocated aeromioclavicular joint. The essential faetor of the operation is the repair of the eoracoclavicular ligament by means of a silk ligature passed around the elavicle and the eoracoid proeess of the seapula. Praetically all subsequent operations have been only modifieations of Watkins' operation, the silk being replaeed by fascial strips or other material. The

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, New Orleans, Louisiana, January 16, 1941.

Fig. 1

Case 1. G. A. Photograph showing function at end of three weeks following operation.

repair of the ligaments of the acromioclavicular joint has been a minor feature in these operations.

Watkins' operation was a decided improvement over those in which the acromioclavicular joint alone was attached by wires or other types of sutures. However, his operation was not only an extensive one, but, in the hands of many surgeons, failed to give a satisfactory result, the convalescence being long and the end result including pain and some impairment of motion.

Based upon the premise that a stable shoulder with full function and with absence of pain is consistent with a loss of continuity in the shaft of the clavicle, or even with a loss of a portion of the bone, the following operation was planned and executed. The report may be premature, as only four patients have been operated upon, all of whom have had what might be termed subluxation or partial dislocation of the joint, but the results were so satisfactory in every respect that the operation is presented so that its true value may be determined by other surgeons. In all the patients the period of disability was short. One patient returned to work at the end of two weeks. There has been no permanent deformity from an upward riding of the remaining portion of the clavicle, and the scar is not disfiguring.

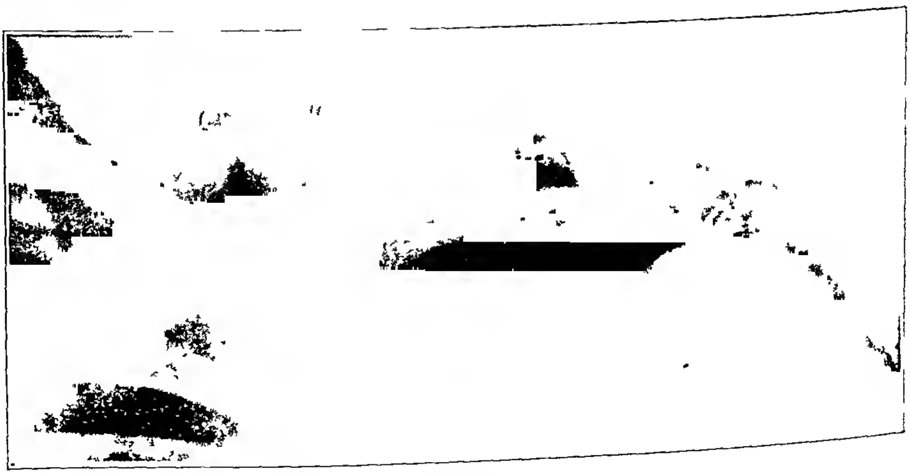

Fig. 2-A

Case 2. C. F. Roentgenogram showing amount of bone removed from the end of the clavicle.

The operation was not done on any patient with complete and permanent dislocation. If there should be a persistent upward riding of the bone, this could be remedied by a fascial suture between the clavicle and the coronoid process. No excision of the sternal end of the clavicle has been done for a painful dislocation at the sternoclavicular joint, although this may be a rational procedure.

FIG. 2-B

Case 2. C. F. Photograph showing function at the end of six weeks following operation.

The operation is simple. A small, curved incision is made over the acromioclavicular joint and a skin flap thrown inward to expose the distal end of the clavicle. With a curved, blunt dissector, the end of the clavicle is freed from all surrounding soft tissue; and, with a sharp bone-cutting instrument, the distal end of the clavicle is cut and removed, together with any meniscus or joint disc that may be found in the joint. The cartilage on the acromion is not disturbed. The soft tissues are then drawn between the cut end of the clavicle and the acromion with catgut sutures, so as to cover the raw surface of the clavicle. No attempt is made to repair the ligaments about the joint. The skin flap is sutured with silk and the arm is held to the side of the body by a Velpeau bandage. This simple fixation is maintained for one week, and then active use of the arm is encouraged. Return to work should be possible within three to four weeks.

CASE 1. G. A., a woman, aged sixty-two, fell and injured her left shoulder four years before she was seen by the writer. Since that time she had had pain and limitation of motion. At the time of examination, the acromioclavicular joint was very tender and the distal end of the clavicle was slightly displaced upward. Abduction of the arm was limited to 90 degrees. Upon exploration of the joint, some proliferation on both the acromion and the clavicle at the joint line was found. The distal three-fourths of an inch was excised and the soft tissues were drawn across the cut end of the clavicle. The arm was carried in a sling for a period of two weeks. At the end of the third week, the patient resumed her household duties with almost complete abduction of the arm (Fig. 1). All symptoms of pain had disappeared.

CASE 2. C. F., a man, aged thirty, injured his left shoulder by a fall. The diagnosis of acromioclavicular dislocation was confirmed by roentgenograms. The shoulder was strapped for three weeks, but limitation of motion and pain persisted. The patient was operated upon eight weeks after the accident, at which time the distal inch of the clavicle was removed (Fig. 2-A). The patient returned to his work in a shoe store at the end of three weeks. Two months after the operation he was doing work of a heavy type, collecting cans of milk along a country route. The end results were full function of the shoulder and absence of pain (Fig. 2-B).

Fig. 3-A
Case 3. R. G. Photograph showing function at the end of four weeks following operation.

Fig. 3-B
Case 3. R. G. Photograph showing postoperative scar.

Case 3. R. G., a man, aged twenty-five, injured his right shoulder playing football. The diagnosis of dislocation of the acromioclavicular joint was confirmed by roentgenograms. The shoulder was strapped for six weeks without relief of the symptoms. An operation was performed six weeks after the accident, at which time the distal inch of the clavicle was removed. The patient returned to work on a delivery truck at the end of two weeks. At the end of four weeks he was free of symptoms, and had complete function of the shoulder (Figs. 3-A and 3-B).

Case 4. L. R., a man, aged thirty, had his left shoulder injured by the fall of a heavy hammer. He had no difficulty for two days, at which time the shoulder became painful, and motion was limited to about 50 per cent. Roentgenographic examination showed a slight displacement in the acromioclavicular articulation. The area over the joint became swollen and red, with evidence of an acute inflammatory condition. The patient was treated conservatively for two months without relief of pain, although the inflammatory condition had subsided. Two months following the accident the distal half-inch of the clavicle was removed. The patient made an uneventful recovery without symptoms, and had full function five weeks after the operation.

The roentgenogram shows the amount of the clavicle removed. The photographs show the range of motion in the shoulder after operation in three of the patients operated upon. Three of the patients were men, all of whom have returned to hard work and are free of symptoms. One was an elderly lady, whose joint showed proliferated arthritic changes, the lesion being of several years' duration. This patient also had a complete return of function in the shoulder without pain.

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Note: Since this paper has been in the Editor's hands, the paper by Fraser B. Gurd on "The Treatment of Complete Dislocation of the Outer End of the Clavicle. An Hitherto Undescribed Operation" has been published in *Annals of Surgery* (Volume CXIII, page 1094, June 1941). This article by Dr. Mumford was therefore prepared without any knowledge of Dr. Gurd's work.—*Editor.*

ONE-PIECE ANGLE NAIL FOR TROCHANTERIC FRACTURES

BY EUGENE L. JEWETT, M.D., ORLANDO, FLORIDA

During the past two years the author has used a Smith-Petersen nail in combination with a flanged plate for five patients with pertrochanteric and intertrochanteric fractures of the femur. The histories of these five patients follow, with illustrations of four.

CASE 1. A woman, seventy-seven years old, sustained an intertrochanteric fracture of the left hip with a detached and displaced lesser trochanter. Figure 1-A shows the fracture a few hours after trauma. This patient was operated upon, and a Smith-Petersen nail and flanged plate were used. The lesser trochanter was anchored to the shaft by means of a long screw. The fragment could not be brought back absolutely to its original site, but the position was improved by the fixation, and it united to the shaft in a very satisfactory manner. Seven and one-half months after operation the woman walked with practically normal motion of the hip joint and only a little limp. Fifteen months after the operation (Fig. 1-B) she was getting about and doing things with no limp or pain. She says that this leg feels stronger than the uninjured one, and she can walk up and down stairs quite satisfactorily.

CASE 2. A woman, seventy-one years old, sustained an intertrochanteric fracture with partial separation of the lesser trochanteric region. Figure 2-A shows the fracture immediately after the accident. She was operated upon, and a Smith-Petersen nail,

FIG. 1-A

Case 1. December 28, 1939, preoperative roentgenogram.

combined with a flanged plate, was used. Fourteen months after trauma she had absolutely no complaints or disability referable to her injured leg (Fig. 2-B).

Case 3. Ten years before she was seen by the author, this sixty-year-old woman had received a clinical and roentgenographic diagnosis of a probable malignancy with a resulting pathological fracture of the femur. Figure 3-A, taken ten years after fracture, shows the bone rarefied through disuse, marked coxa vara from contracture of the soft tissues between the ilium and the proximal fragment, and an ununited fracture. Figure 3-B shows the long screw and flanged plate in place. The bone was so decalcified that there was danger a Smith-Petersen nail would split it or pull loose too easily; therefore, a long screw was used instead. Eighteen months postoperatively she had a perfectly solid union, with very good painless use of the leg. She has two inches of shortening, which is compensated for by a raised shoe. No attempt was made to correct the contracture of the gluteal and other supratrochanteric soft structures, as a ten-year interval results in too much contracture to be relieved except by a great deal of surgery, which was not indicated in this patient.

Fig. 1-B

Case 1. March 13, 1941, one year and three months following operation.

Case 4. A woman, seventy-five years old, had an intertrochanteric fracture with quite a bit of comminution around the fracture site. She was operated upon a few hours after trauma, and a Smith-Petersen nail and flanged plate were used. Figure 4-A shows the immediately preopera-

Fig. 2-A

Case 2. January 15, 1940, preoperative roentgenogram.

Fig. 2-B

Case 2. March 20, 1941, one year and two months following operation.

Fig. 3-A

Case 3. October 5, 1939, preoperative roentgenogram.

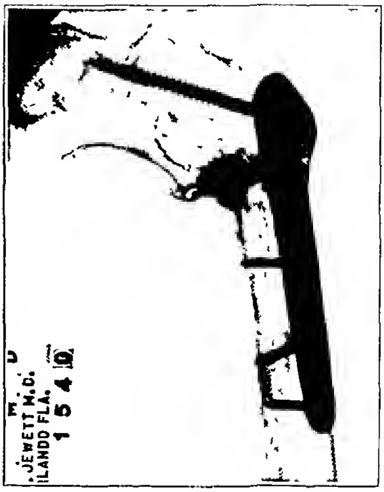

Fig. 3-B

Case 3. November 15, 1940, thirteen months following operation.

tive condition. Figure 4-B shows the roentgenographic result four months after trauma, at which time she was getting about fairly well with almost complete weight-bearing. Twelve months postoperatively (Fig. 4-C) she was walking about with practically no limp, no disability, and no pain whatsoever, except slight twinges during damp or cold spells.

Case 5. A seventy-six-year-old woman sustained a trochanteric fracture with separation of the lesser trochanter. The Smith-Petersen nail and Hawley bone plate were used. The lesser trochanter was anchored by means of a screw. Three weeks after the operation the patient was up and about with crutches, and was rapidly obtaining excellent painless motion of that joint. Latest reports from her reveal that she is walking with a solid limb without the use of crutches or a cane, and with only slight limitation of motion and a little pain on certain movements. To all intents and purposes, she has a good result, especially since she is now about seventy-eight years old.

These patients were all operated upon under fifty or sixty milligrams of avertin per kilogram of body weight. In five of the cases, either gas-oxygen or ethylene supplementary anaesthesia was used, and in one case local infiltrated novocain was employed. The author does not use barbiturates or opiates preoperatively with avertin. Of course, atropine is indicated with any inhalation anaesthesia. The trauma necessary to operating on these elderly people is reduced to the lowest minimum, and a thorough medical check-up is undertaken in each case. Forced carbohydrate feeding for a couple of days before operation is strongly advocated, and any noticeable anaemia should be corrected either by medication or blood transfusion.

There was no postoperative cast applied, and no retentive apparatus of any type used, except occasionally sandbags placed along the limb for a day or two. The patient was put in Fowler's position as soon as possible, was turned from side to side at least twice a day, and was encouraged to take deep-breathing exercises and move about as much as possible. She was allowed out of bed when the sutures were out (on the ninth day), and encouraged to walk with crutches after two or three weeks, if such

Fig. 4-A

Case 4. March 15, 1940, preoperative roentgenogram.

Fig. 4-B

Case 4. July 15, 1940, four months following operation.

Fig. 4-C

Case 4. March 14, 1941, one year following operation.

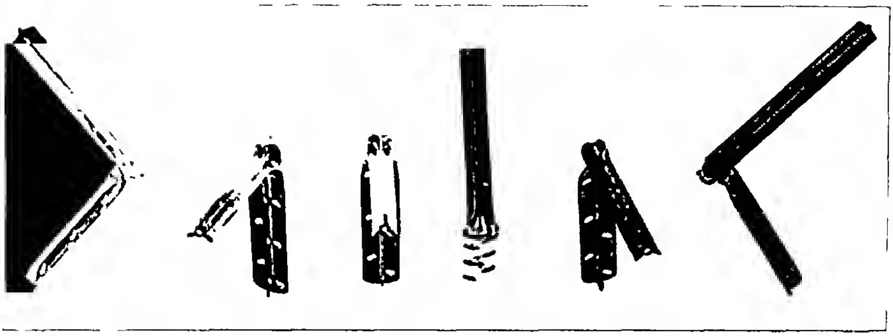

FIG. 5
One-piece hip angle nail.

was deemed safe. Full weight-bearing was allowed only when roentgenograms showed that there was absolutely solid union.

These patients have all done well, though it was felt that there were several unsatisfactory features about the procedure. First, there was no way that rotation of the flange on the Smith-Petersen nail could be prevented except by the friction between the rim of the nail, the socket of the flange, and the head of the screw. Were the screw to become the least bit loose there would be practically nothing to prevent rotation of the flange on the pin. Second, the screws in the flange were all in the same line, and there was not enough force there to prevent slight rotation or movement of the femur on the flange. Third, excessive metal protruded above the bone where the flange capped the Smith-Petersen pin. This feature has been somewhat eliminated in the much lighter and thinner flange manufactured by another company, but this apparatus still retains the other undesirable features outlined above. In one patient the author had a great deal of difficulty in screwing the flange to the nail because the Smith-Petersen pin was not driven in at quite the correct angle. It had to be withdrawn and redriven, so that the coaptation screw could be put in with the flange lying along the bone and still capping the Smith-Petersen pin at the correct angle.

With the idea of correcting the above features the author devised the one-piece flanged nail, which is merely a one-piece combination of the Smith-Petersen nail and a Hawley-type bone plate, but which greatly facilitates the technique of operation. This one-piece combination has been used in two cases with, so far, excellent results. However, these cases have been of such short duration that they are not being reported at present.

Figure 5 depicts fairly clearly the construction of the nail which may be made of vitallium or stainless steel. The flange is curved, so as to fit the surface of the femur, and permit the screws to slant toward each other when they enter the bone. This leads to much firmer anchorage than if they were parallel, and is especially true when the screws transfix both cortices of the bone, as they should always do. It may be that firm

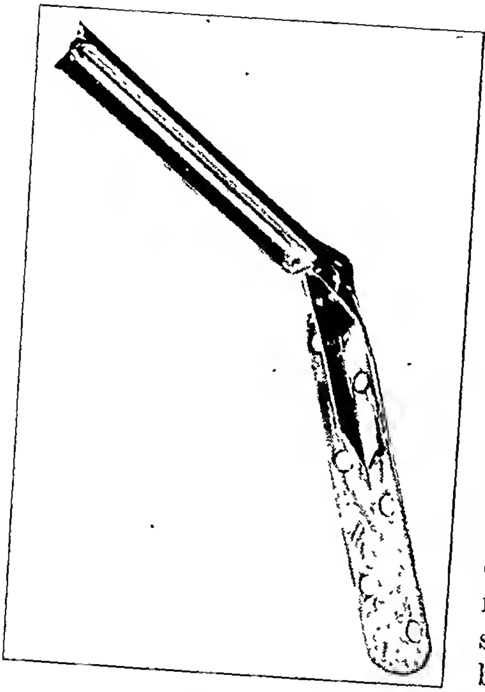

FIG. 6

One-piece hip angle nail with short flange.

enough fixation would be accomplished without the use of the under flange, which fits into a slot in the bone. Without this angled feature, of course, it would be much easier to insert and attach the apparatus, but whether or not this would give enough anchorage would have to be determined by trial. The author believes that the Hawley angle feature insures greater stability, which in these fractures is desirable, but if there is any difficulty in marking a long enough groove in the femoral shaft to accommodate the under arm of the flange, this flange can be greatly shortened and still give enough stability to obtain the desired immobilization (Fig. 6).*

In using this nail there is nothing out of the ordinary to be recommended. The operator may use any method for driving in the nail. By the author's technique, the fracture is reduced by traction and manipulation, confirmed by roentgenograms, and then the patient is operated upon. Small Steinmann wire pins are used as guides, with a roentgenographic check. The nail is then threaded over the correctly placed pin and driven in. The slot for the under arm of the T-flange is easily made with a bone saw, although it can be fashioned by means of drill holes and a very thin-bladed osteotome. In the latter instance, however, care must be taken not to fracture the bone. The nail must be driven in with the flange plate kept parallel with the femoral shaft. It would not make a great deal of difference whether, as is desirable in such fractures, the Smith-Petersen nail were directly in the center of the neck of the femur throughout its course or not. The average angle made by the neck and the shaft is 120 degrees, and with the separate flanged-nail unit there are several different angles made, so as to apply to necks of different angles. However, by keeping the flanged arm of this single-unit flanged nail parallel with the shaft, the nail can be driven in, even though it does not go directly down the center of the neck in each case. In these trochanteric fractures, the pin is merely a stabilizing arm and does not necessarily bridge the fracture site, except where the fracture line is proximal to the lower intertrochanteric ridge. Where it is desired to keep a considerable stock of these nails on hand at all times, it would

* Since this paper was written the shorter-flanged one-piece nail has been used on three additional patients and has been found to be much better than the long, full-length ones. The groove can be made with just a few drill holes and an osteotome, and does not necessitate the use of a bone saw.

be a simple matter to have them made up with different angles.

Another problem which has puzzled the author has been what to do with the detached loose lesser trochanteric fragment. The general practice has been to ignore this condition, and the author can find no mention in the literature of any attempts to anchor it. We are all familiar with the pain associated with movement of the hip joint, where such a fracture is present. The iliopsoas muscle, which inserts into the lesser trochanter, and the pectineus, which along with the iliacus inserts a little below the lesser trochanter, tend to displace this fragment upward during movement or contraction. Pain ordinarily persists for several weeks, during which time not only is hip motion painful, but the lesser trochanter may be pulled quite a distance proximally from its original site. Many times an excessive callus weld is thrown out because of this migration and more or less constant irritation, even though the fragment seldom fails to unite. The excessive weld of callus often impairs the painless full range of motion of the joint. With this problem in mind the author began to anchor this fragment to the femur with a screw (Fig. 7), and found it was a comparatively easy thing to accomplish during any surgical fixation for the neck or pertrochanteric region. The fingers can be placed around anterior to the bone, and the lesser trochanter can be easily pulled into place without any danger to the overlying blood vessels or nerves. In some cases the entire procedure can be done under full subperiosteal exposure. With this fragment anchored in place, the patient can move about and sit up in bed with very little pain a day or two after the operation. This is a sound procedure and certainly does not add much trauma to any operation on the upper end of the femur or neck.

FIG. 7

Showing (a) the one-piece hip angle nail in place, and (b) the separate fixation of the lesser trochanteric fragment.

CASE 6. A seventy-eight-year-old woman suffered an intertrochanteric fracture of the left hip with complete detachment of the lesser trochanter. Figure 7, taken six weeks following the operation, shows this patient with the author's one-piece flanged nail in place. The lesser trochanter had first been fixed to the shaft by an extra screw. She has had a remarkedly easy time of it so far. She has been up in a chair since one week after the operation, and has been able to move her leg fairly easily since the second day. After this roentgenogram (Fig. 7) was taken, she was allowed to begin gradual weight-bearing, with the help of nurses, of course. She absolutely refuses to use crutches. She has almost complete painless range of motion of the hip with only a little tenderness about the fracture site, and still some atrophy of the leg.

It is too early to report the end result of this case; it is presented merely to show the one-piece flanged nail in use, and the separate fixation of the lesser trochanteric fragment.

SUMMARY

The use of both the Smith-Petersen nail and the Hawley bone plate has given good results in five patients. The difficulties encountered in their combined use have been greatly lessened by welding them together into a one-piece flanged nail. Shortening the flange has still further simplified the use of the one-piece flanged nail.

The advantages of anchoring the "floating" lesser trochanter to its bed by screw fixation are definite and warrant the slight added operative time and trauma.

BONE TUBERCULOSIS IN NORTHERN NEWFOUNDLAND

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Tuberculosis is the most common cause of death among the people of Newfoundland and southern Labrador. In this Hospital of 100 beds there were 8,778 admissions in the fifteen years from January 1923 to December 1937, 10.11 per cent. of which were for tuberculosis. (See Table I.) Of the total admissions, 3.05 per cent. were for bone tuberculosis.

The people treated are chiefly fishermen of British ancestry. The climate is cold and damp with much foggy weather. The standard of living is low among the fishermen. For six to eight months of the year many of the people live entirely on white bread and tea, with perhaps a small amount of butter and a few potatoes. Beriberi is still very common in many sections. This survey includes three Labrador Eskimos.

It is hoped that, in the future, studies can be made as to the relative prevalence of the bovine or human bacilli in the cases of bone tuberculosis. It can only be said that pulmonary tuberculosis is very common in Newfoundland, and that a large percentage of cattle are thought to be infected with bovine tuberculosis.

The care of these patients has been chiefly under the direction of the senior author, although several visiting surgeons, including Dr. J. T. Rugh of Philadelphia and Dr. Arthur Krida of New York, treated some of them during a summer visit of a month or more at St. Anthony.

During the fifteen years of this study, 175 patients were admitted to the Hospital 268 times with bone tuberculosis. Last year an attempt was made to reexamine the patients within reach, and a form letter was sent to the remainder. Follow-up examinations or letters made possible the securing of information from 157 of these patients, or 89.7 per cent. The average follow-up period was eight and nine-tenths years.

In analyzing the results of treatment, the patient's condition will be referred to as excellent, if he is able to do hard manual labor; as good, if he can do light work; as fair, if he uses a crutch or other type of support; and as poor, if he is bedridden. In the case of multiple bone lesions, the patient is classified only under the first joint for which he received treatment.

As has so often been emphasized, bone tuberculosis is not a specific disease of a particular part of the skeleton, but is a local manifestation which has had its source elsewhere, and which is frequently accompanied by tuberculosis of another organ. For this reason, the case summaries will be divided into two groups: those that have no other clinical evidence of tuberculosis, and those that have other tuberculous foci in the lungs, genito-urinary tract, peritoneum, other bones, or elsewhere. Any patient who has had a history of other tuberculous foci, even though apparently

TABLE I

Admissions for All Forms of Tuberculosis from January 1, 1923 to December 31, 1937

Location of Lesion	No. of Cases	Percentage of Total Admissions *	Percentage of Admissions for Tuberculosis
Lungs	473	5.39	53.2
Bone	268	3.05	30.2
Peritoneum	38	0.43	4.3
Testicle	30	0.34	3.4
Lymph glands	24	0.27	2.7
Meninges	23	0.26	2.6
Kidney	16	0 18	1.8
Tubes and ovaries	6	0.07	0.7
Skin	5	0.06	0 6
Appendix	1	0.06	0.1
Intestines (unclassified as to type)	1		0 1
Sclera of eye	1		0.1
Breast	1		0.1
Mesentery	1		0.1
Total	888	10.11	100.0

* Total admissions for the period were 8,778.

healed at the present time, will be included in the second group. The authors feel, that while there may be no clinical evidence of activity in the former seat of disease, one can never be sure that an old smouldering tuberculous focus will not flare up and cause death from meningitis or pulmonary disease. This was strikingly exemplified recently in the case of a forty-six-year-old man, who had a tuberculous hip twenty-one years ago, and who died quite suddenly of tuberculous meningitis. He had led an active life with an ankylosed hip for many years. Only two months before his death he had a thorough examination, including a urinalysis, and roentgenograms of the chest, which showed no evidence of tuberculosis.

This Hospital has a limited staff, and, at times, limited facilities, so that complete work-ups and roentgenograms, particularly of the lungs and kidneys, were not done in all cases. However, great care has been taken in classifying the patients into the groups with and without tuberculous foci. History, physical examination, and sputum and urine examinations have been evaluated when roentgenograms were not available. Roentgenograms have confirmed all but three of the joint lesions; these patients were felt to present a clear clinical picture of bone tuberculosis.

TUBERCULOSIS OF THE SPINE

This series includes seventy-eight cases of tuberculosis of the spine, an incidence of 49.7 per cent. of the joints involved in the 157 patients followed. (See Table II.) The vertebra most frequently affected was

TABLE II

RELATIVE FREQUENCY OF JOINTS INVOLVED IN THE PATIENTS FOLLOWED

Location of Original Bone Lesion	Number of Cases	Percentage of Total Bone Tuberculosis
Spine	78	49.7
Hip	26	16.5
Knee	24	15.3
Foot and ankle	17	10.8
Shoulder	5	3.2
Elbow	3	1.9
Wrist	2	1.3
Sacro-iliac	2	1.3
Total	157	100.0

the twelfth thoracic, with the fourth and fifth lumbar vertebrae close seconds. Those patients having involvement of the lower thoracic and lumbar regions showed the best response to treatment. Patients with upper thoracic and cervical lesions responded less favorably.

It has been the general policy to operate on all patients who are not too poor risks, as this Hospital is small and a rapid turn-over of patients is essential. The patients receiving non-operative therapy include those who were judged poor operative risks, those with sinuses or paralyses, and those refusing operation. The usual routine has been operation after a varying period of from one month to two years' observation. By far the greater number were operated upon within one or two months of admission. The Albee procedure was followed in all but two patients, in whom the Hibbs operation was performed. Before operation the patient had anterior and posterior plaster shells prepared, in which he was immobilized for three months postoperatively. The patient was then fitted with a brace which he was instructed to wear for a year at home.

Those in the non-operative group were treated by Bradford or Pyrford frames, casts, and braces. A few refused all treatment. The results are tabulated in Table IV. It may be seen that 82.4 per cent. of the patients with no other clinical focus of tuberculosis stand a chance of leading a useful life after operation, following as short a time as four months of hospitalization. If, however, they have or have had other foci of tuberculosis, operation has nothing to offer. In the small series of patients falling within this group, those having operation did no better than those treated conservatively, when it is realized that the patients who were operated upon, were considered the better risks. The mortality in all patients with tuberculosis of the spine was 35.9 per cent. The mortality in patients who were operated upon and who had no other foci, was 8.8 per cent. Three patients with tuberculosis of the spine and no other foci, who have since died, have not been included in our mortality figures.

TABLE III

SUMMARY OF CASES SHOWING PERCENTAGE OF MORTALITY FOLLOWING OPERATIVE AND NON-OPERATIVE TREATMENT

Location of Original Bone Lesion	Number of Patients	Operative Group: No Other Tuberculous Foci Present	Operative Group: Other Tuberculous Foci Present	Non-Operative Group: No Other Tuberculous Foci Present	Non-Operative Group: Other Tuberculous Foci Present
Entire series					
Patients	157	54	32	45	26
Deaths	45	5	19	8	13
Mortality per cent	28 7	9 3	59 4	17 7	50 0
Spine					
Patients	78	34	22	13	9
Deaths	28	3	14	4	7
Mortality per cent	35 9	8 8	63 7	30 8	77 8
Hip					
Patients	.26	6	5	9	6
Deaths	7	0	2	2	3
Mortality per cent	26 9	0	40 0	22 2	50.0
Knee					
Patients	24	7	3	10	4
Deaths	4	0	2	1	1
Mortality per cent	16 7	0	66 7	10 0	25 0
Foot and ankle					
Patients	17	6	2	5	4
Deaths	3	1	1	0	1
Mortality per cent	17 6	16 7	50 0	0	25 0
Upper extremities					
Patients	10	1	0	7	2
Deaths	2	1	0	1	0
Mortality per cent	20 0	100 0	0	14 3	0
Sacro-iliac					
Patients	2	0	0	1	1
Deaths	1	0	0	0	1
Mortality per cent	50 0	0	0	0	100 0

They were in excellent health and lived normal lives seven, eleven, and twelve years after operation, and died from causes totally unrelated to their tuberculous disease,—one from drowning, one from lobar pneumonia, and one in childbirth. The mortality in those receiving non-operative treatment was 30.8 per cent. These figures compare favorably with others reported in the literature.

This series includes seven patients with paralyses, six, or 85.7 per cent., of whom had no other foci. Four were treated conservatively with one death from pulmonary tuberculosis. One was operated upon while paralyzed, one during recovery while still spastic, and one after recovery of motion. Of these, two had excellent results, and the third, good.

Three patients had a second Albee operation because of extension of the

TABLE IV

RESULTS FOR PATIENTS WITH TUBERCULOSIS OF THE SPINE

Result	No Other Tuberculous Foci Present				Other Known Tuberculous Foci			
	Operative		Non-Operative		Operative		Non-Operative	
	No.	Per Cent	No.	Per Cent	No	Per Cent	No	Per Cent
Excellent	20	58 8	5	38 4	4	18 2	1	11 1
Good	8	23 6	2	15 4	2	9 1	0	0 0
Fair	2	5 9	1	7 7	1	4 5	1	11 1
Poor	1	2 9	1	7 7	1	4 5	0	0 0
Dead	3	8 8	4	30 8	14	63 7	7	77 8
Total	34	100 0	13	100 0	22	100 0	9	100 0

disease. Two of these, with other tuberculous foci, died. In three patients infection developed postoperatively, in two of whom the grafts sloughed. The first reports his condition as excellent, the other two as good, though one still has a sinus with intermittent drainage (six years postoperatively).

In the recent symposium on spinal tuberculosis,[3] attention was drawn to persistent abscesses and their relation to lack of clinical improvement. In this series, 55 per cent. of the patients showed clinically or by roentgenograms the presence of abscesses. The mortality in this group was 23 per cent., and in the group without abscesses and without other tuberculous foci, 15 per cent. Although this would tend to show a poor prognosis in this group, the records and roentgenographic reports are not complete enough to draw further conclusions.

Four patients with draining sinuses received operative treatment, one with excellent, two with good, and one with fair result. One of these still has a draining sinus, six years postoperatively. Two patients treated conservatively are both living, one with a good and the other with a fair result. In the group with other tuberculous foci and sinuses, there were five patients, only one of whom was treated operatively. All have since died. In two patients sinuses developed after leaving the Hospital. One of these patients was operated upon.

Ten children under twelve years of age have been treated, all of whom had no other tuberculous foci. Six were treated operatively and four conservatively, with one death in each group. The death after operative treatment was from lobar pneumonia twelve years later. The child had previously been in perfect health. The other death was from tuberculous pneumonia. The youngest child treated operatively was aged three. The result was excellent three years later. This series is too small to draw conclusions concerning the preferability of operative or conservative therapy in children.

TUBERCULOSIS OF THE SACRO-ILIAC JOINT

Of the two patients with tuberculosis of this joint, one had other foci and died, the other was treated conservatively with a cast for seven months and then with a brace. Now, six years later, he is in excellent health.

TUBERCULOSIS OF THE HIP

The hip was found to be the second most common location of bone tuberculosis, occurring twenty-six times in this series. Thirteen operations were performed on eleven patients. An extra-articular fusion was performed eleven times,—six patients had tibial grafts, and five, a bone flap from the outer table of the ilium to the trochanter. The Chandler operation was performed twice. Two of the patients who had had a fusion with a graft from the tibia needed a secondary operation, because of non-union of one end of the graft. There were two deaths in this group, both occurring several years after operation and in patients with other tuberculous foci. All other patients who were operated upon had excellent or good results. All patients who received operative treatment report stiff joints. In the group who were not operated upon, six report stiff joints, three report motion in their hips, and one failed to report.

One of the patients operated upon had sinuses. Five patients with sinuses were treated conservatively. One patient in each group developed sinuses following discharge from the Hospital. In the three patients with sinuses and no other foci, the results were favorable.

Of the six children receiving treatment three, aged eight, ten, and eleven, had a stabilization operation, with two excellent results and one good. Another child was treated conservatively in a spica for three years, then discharged, returning ten years later for operation. Now, six years after operation, she has a good ankylosis, is able to work, but is still annoyed by a persistent draining sinus. Two children received conservative treatment with one excellent result and one fair. The latter has persistent pain in his hip and is anticipating an operation shortly.

TUBERCULOSIS OF THE KNEE

There were twenty-four cases of tuberculosis of the knee, making this the third most frequent site of involvement. Ten patients received operative treatment. In nine a resection of the knee joint, as advocated by Henderson, was performed. One had an amputation because of the extent of involvement of the knee joint. Another had an amputation six months after operation, because of non-union and increased activity of the disease. Of the seven patients who had a resection, but no other tuberculous foci, three report their results as excellent, two as good, and one as poor. From correspondence with the seventh patient, it would seem that renal tuberculosis had developed. Those patients with uncomplicated tuberculosis of the knee, treated by resection, averaged only four and one-half months' hospitalization.

Among the patients not operated upon, there were ten without,

and four with, other tuberculous foci, with a single death in each group. Of the former, three report excellent results, two good, and one poor. Taking the group as a whole, 54 per cent. are now in excellent health, which makes this the most favorable joint for treatment.

Three patients with sinuses were treated conservatively with good results.

Five children were treated conservatively with no deaths. Three report their condition as excellent with stiff knees; one as good with partial restriction of movement; and one as fair with no ankylosis. Roentgenograms in all these cases reveal joint involvement. While this group is very small, the results are quite different from those of McKeever, who reports no satisfactory results with conservative treatment in forty-six out of forty-seven children. However, these results with conservative treatment still fall short of McKeever's results following operation.

TUBERCULOSIS OF THE ANKLE AND FOOT

Seventeen patients were treated in this group. Eight received operations and nine were treated non-operatively. Six patients had a Syme amputation of the leg, and two had an arthrodesis of the ankle. The authors have had excellent results with the Syme operation, which was first described by Sir James Syme of Edinburgh in 1843, and used by him as a substitute for higher amputation of the leg in tuberculosis involving the ankle joint. The Syme operation was gradually forgotten, but after the World War I attention was again called to this excellent operation by Wilson. All patients with no other tuberculous foci, who had a Syme amputation, are living. These cases were in adults who are carrying on very strenuous lives,—fishing, and dog driving. Three operations were done over fifteen years ago. Four patients with sinuses were operated upon (Syme amputation), and three were treated conservatively. The sinuses have all healed and patients report their condition as excellent.

Five children with this condition were treated conservatively with casts or heliotherapy and all are well.

TUBERCULOSIS OF THE UPPER EXTREMITIES

There were five cases of tuberculosis of the shoulder, three of the elbow, and two of the wrist. Of these ten cases, eight were uncomplicated, and two patients had other tuberculous foci. Involvement of the shoulder seemed to occur more frequently in cases of multiple bone foci than of the other joints. Tuberculosis of the hip later developed in one patient, tuberculosis of both elbows in another, and tuberculosis of the spine and shoulder in a third, who was listed under tuberculosis of the hip. All of this group, except one, were treated conservatively with braces, collar slings, casts, etc. This one patient had an amputation of the lower forearm for tuberculosis of the wrist. There were two deaths in this group, neither of whom had other tuberculous foci. The patient who had the amputation died thirteen years later of pulmonary tuberculosis.

COMMENTS

From these results the futility of operating upon patients with other tuberculous foci is evident. The authors feel that all patients with bone tuberculosis should have roentgenograms made of the chest, and, where symptoms or urine suggest renal tuberculosis, a thorough urological examination. It would seem that in a general Hospital, such as this, conservative treatment, especially in cases of spinal and hip tuberculosis, cannot be carried out properly, as much of the care of these patients is delegated to general duty nurses and hospital aides, who have neither the background nor the time required for proper handling of orthopaedic cases. As has been previously mentioned, the time of hospitalization is another factor that has to be considered. If a patient can receive operative treatment and be out of the hospital in three to six months, rather than after several years, such treatment would seem preferable from the viewpoints of both the hospital and the patient.

In tuberculosis of the hip, the best results have been obtained by an arthrodesis employing the bone flap from the ilium. In this small series none of the patients needed a second operation for non-union. The chances of infection are less with one incision than with two. This operation has been equally satisfactory in adults and children.

In tuberculosis of the knee, the Henderson type of resection has been found to give very satisfactory results in adults. The authors have had no experience with operative treatment in children.

In tuberculosis of the ankle in adults, the Syme operation is an ideal form of treatment, and may be classified as a conservative operation, eliminating as it does the focus of the disease, and giving an excellent functional result. In children conservative treatment is indicated.

In all twenty-seven children, twelve years and under, there was one death related to the patient's tuberculosis. It is a significant fact that at the time of treatment only one of these children had clinical evidence of other forms of tuberculous disease. This would seem the most likely reason for the good prognosis in children.

The authors have not found that the presence of tuberculous sinuses has in any way altered the patients' prognoses.

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THE SHELF OPERATION FOR CONGENITAL DISLOCATION OF THE HIP

A New Technique for the Old Irreducible Dislocation *

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In the old dislocated hip with defective acetabulum, the shelf operation provides the best method of obtaining stability. This is especially true when the hip can be reduced into the primary socket. Great difficulty has been experienced in the construction of a suitable shelf in the high dislocations, when the acetabulum is obliterated and the upward dislocation is so great that restoration of the head of the femur to the primary socket cannot be obtained. It is the purpose of this paper to present an operative technique for this type of dislocation, which the writer has found meets the requirements for producing a stable, workable hip joint.

The important factors to be considered in the production of such a shelf are:

1. A heavy, wide ledge of bone which fully covers, and extends well in front of and behind, the head of the femur.
2. A downward sloping ledge of bone which retains its blood supply.
3. A suitable bed which will allow the head of the femur to mold a deep, stable socket, and which will function on the order of the original acetabulum.

When a patient is considered a proper subject for the shelf operation, skeletal traction is applied for a period of from two to three weeks in order to relax the ligaments and muscles, and to gain as much length as possible.

OPERATIVE TECHNIQUE

First Stage

The patient is placed on the operating table face down and the surgical field is prepared over the posterior ilium opposite the side of the dislocation. A curved incision is made conforming to the crest of the ilium. A large wedge of bone is removed, beginning well up at the crest, and cut deep to the inner table of bone, measuring about two and one-half inches in length and two inches in width (Fig. 1). This can be trimmed to suit when ready for placement beneath the roof in the second stage of the operation. The incision is closed and dressings are applied.

Second Stage

The patient is turned on his back, and the hip is prepared. The leg and thigh are draped so that the leg can be moved freely without the danger of contaminating the operative field.

* Read at the Meeting of the North Pacific Orthopaedic Society, Portland, Oregon, November 23, 1940.

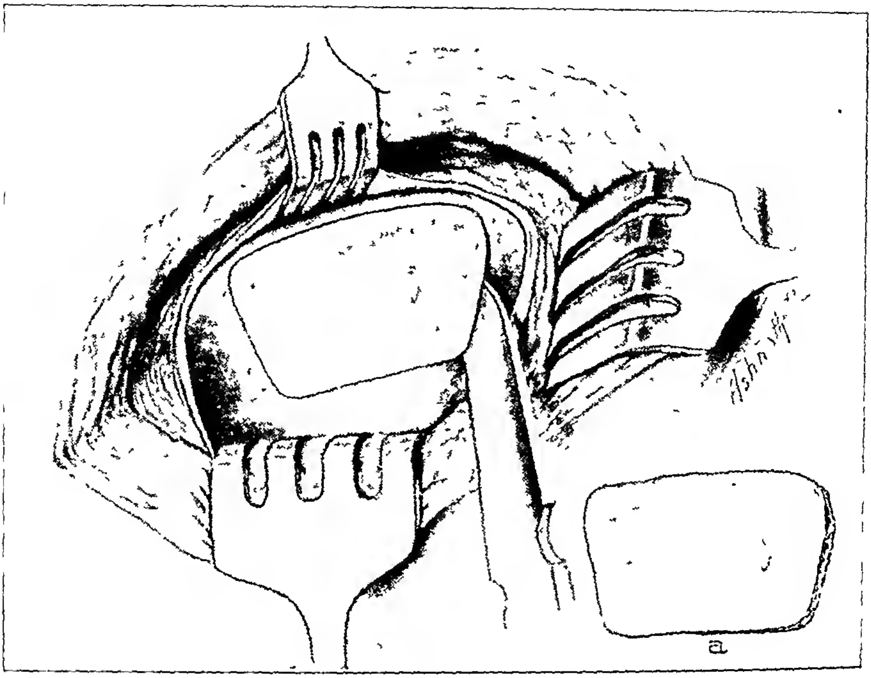

FIG. 1

Supporting wedge is taken from the posterior ilium in the first stage of the operation.

A Smith-Petersen incision is made beginning well back on the ilium. The gluteal muscles and periosteum are freed downward. The rectus femoris and sartorius attachments are pushed upward and retracted well out of the field. The superior attachment of the capsule is displaced downward with the periosteal elevator to the rim of the primary acetabulum. The capsule is trimmed of its excess bulk (Fig. 2). The leg and thigh are flexed to 90 degrees and adducted, in order to displace the head downward and backward. This provides a good view of the operative field above the capsular attachment. With a sharp osteotome a bone flap is outlined (Fig. 3) and cut deep to the inner table; the lower cut is parallel to the upper edge of the old acetabulum and about two and one-half inches in diameter, and the vertical cuts extend upward for a distance of from three to three and one-half inches. With a curved chisel the flap is then freed at the lower border from the inner table of bone, and the chisel is driven upward until the flap is free to the upper extremity of the vertical cuts. The flap is teased outward and the wedge from the posterior ilium is trimmed to suit and inserted beneath the flap with the thicker side directed downward (Fig. 4). Then by lowering the leg and thigh the head is carefully eased beneath the flap (Fig. 5). The incision is closed and a hip-spica cast is applied with the leg slightly abducted. The original cast remains on for a period of twelve weeks. A short spica is then applied, and weight-bearing is permitted for one month in the cast.

Nine patients have been operated upon in this manner over a period of two years. Eight are now walking without support and have strong,

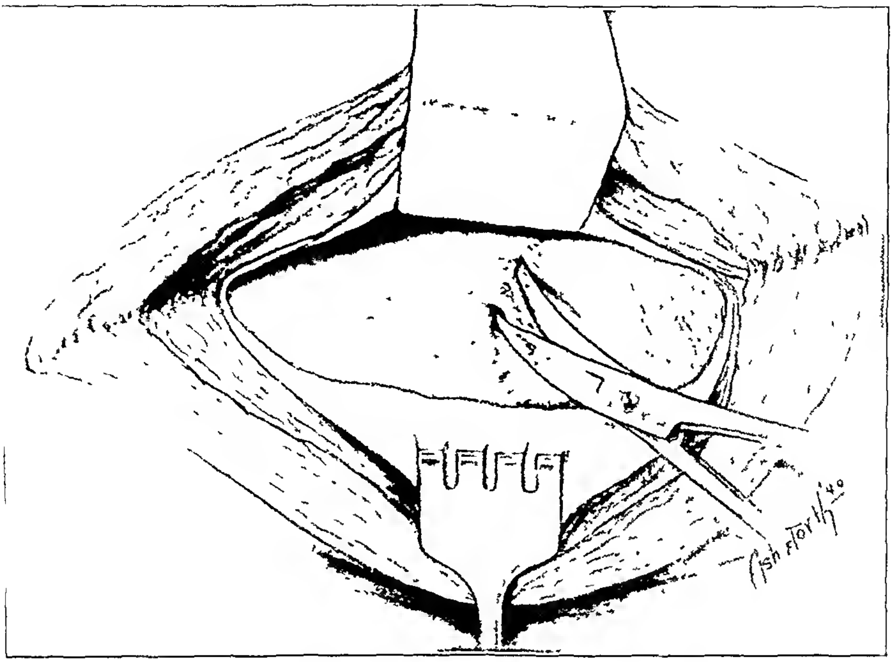

Fig. 2

Following the exposure of the capsule, it is trimmed of its excess bulk.

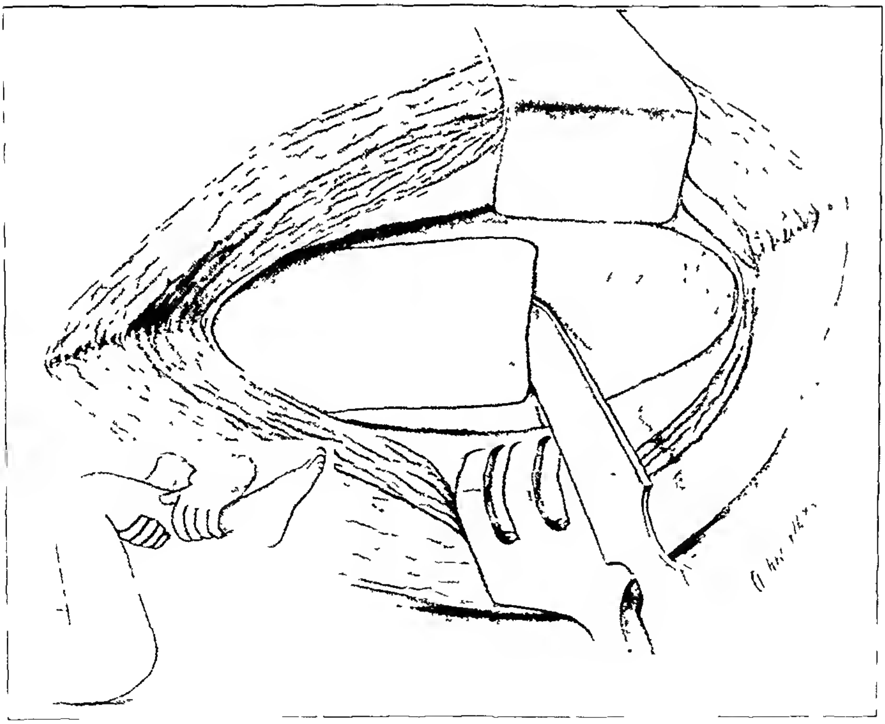

Fig. 3

Primary outline of the bone flap cut deep to the inner table of bone. The thigh and leg are flexed and adducted.

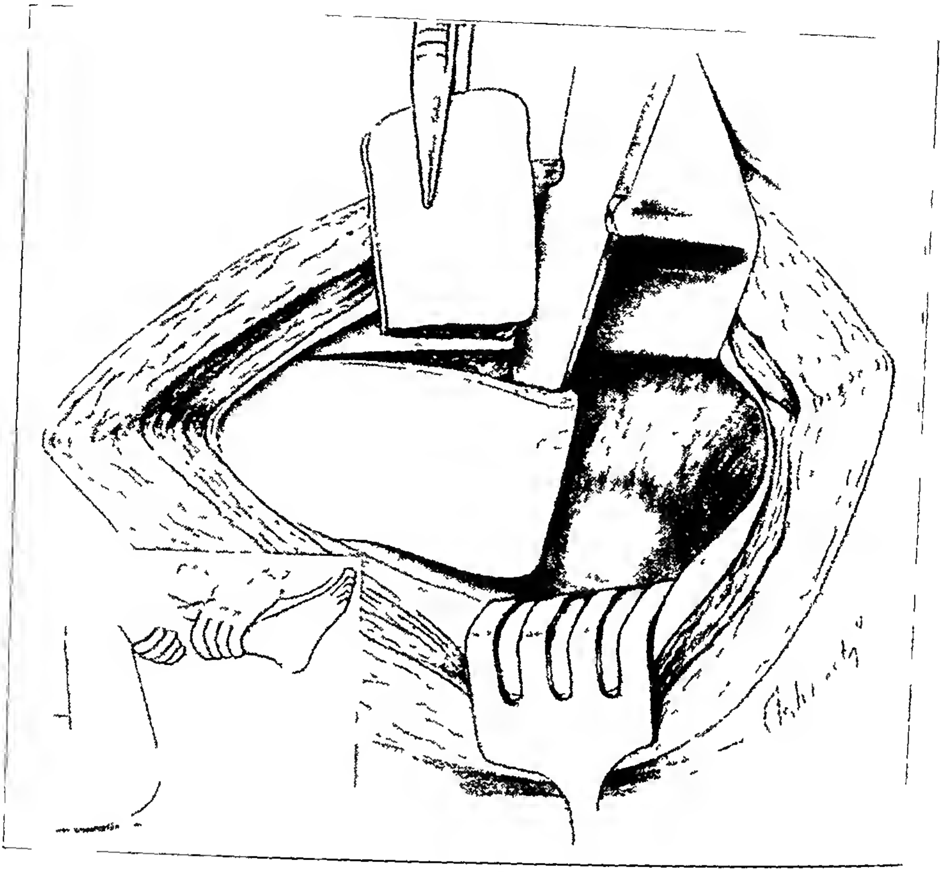

FIG 4

The bone flap is gently elevated and the bone wedge inserted beneath it Note the depressed head of the femur, which is due to flexion and adduction of the thigh and leg

stable hip joints The Trendelenburg test was absent in these eight cases. In one patient (Case 5) the bone flap was absorbed. This child was allowed up with full weight-bearing in eight weeks. This, the author feels, was too early, and possibly was a contributory factor in the failure. In this patient the Trendelenburg test is still present. In two patients the flap was partly broken at its base during the operation, because of a too rapid elevation, but it remained vital.

Deep sockets with a heavy supporting ledge of bone have been obtained as evidenced by the roentgenograms (Cases 1, 2, 3, and 4). Serviceable hip excursion is produced early by active physiotherapy and use of the limb.

The supporting wedge should be taken from the posterior ilium near the crest and deep to the inner table of bone, since a thicker graft can be obtained here. It also obviates weakening the ilium in front above the shelf, and lessens the trauma to the primary surgical field. Projection of the shelf laterally to the level of the trochanter is not undesirable as excess bone rounds off and is absorbed and there is no undue interference with abduction.

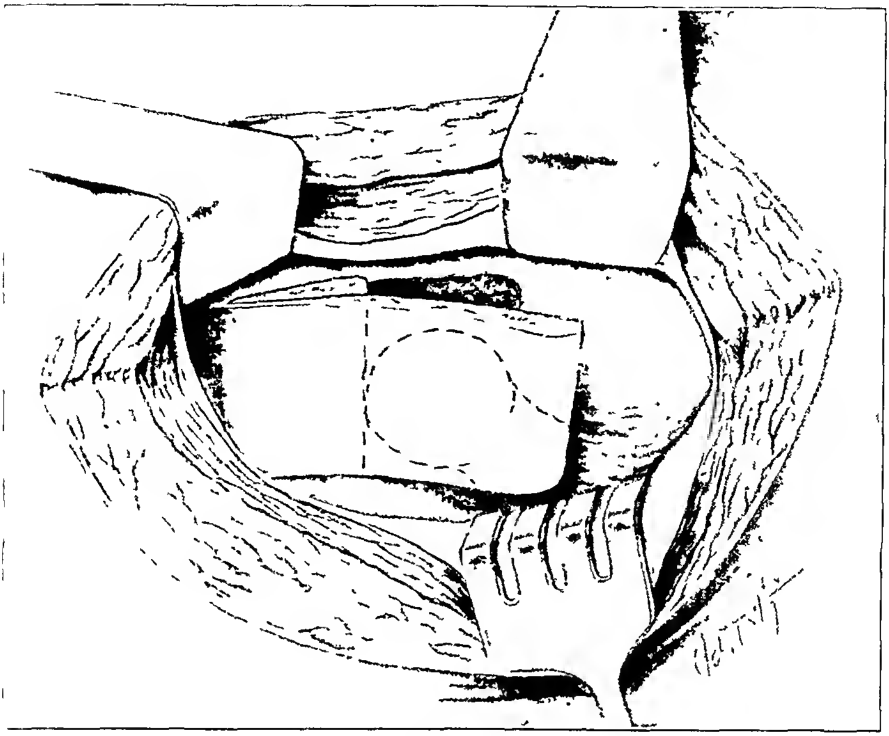

FIG 5

The head of the femur is shown beneath the flap with the supporting wedge in place above the head.

This operation provides an articulation which corresponds more closely to the primary socket, and the load on the hip muscles is decreased as compared to that of the shelves which depend entirely on bone wedges extending outward from the surface of the ilium.

The hip should be brought down, as far as possible, before the operation by skeletal traction, in order to stretch the ligamentous and muscular tissues, and to gain length. Traction during the operation is not necessary, as flexion of the thigh and leg, in conjunction with deep anaesthesia, affords good mobility of the head and permits it to be easily displaced from the operative field.

It is important that the head with its capsule be well freed, so that the head can be brought forward above the site of the primary acetabulum. The capsule in no case should be cut through in order to release the head. Kidner [1] has shown that the capsule may be attached to the ilium for an inch or more above the acetabulum. It can be separated from the ilium with the periosteal elevator down to the primary rim. A great deal of the thickened capsule should be trimmed away in order to do away with an excess of bulky tissue.

Many failures in other operations described are due to not placing the graft firmly against the head of the femur. If a gap is allowed to exist between the head and the prepared ledge, there may be an unstable,

weak joint and a continuance of the positive Trendelenburg. This in turn leads to the likelihood of redislocation of the head from beneath the shelf. If the shelf does not contact the head firmly, there is a greater tendency toward absorption of the shelf several months following the operation, because of increased excursion and constant forcible upward thrusts against the new bone.

The operation described provides a wide shelf that covers the head well, and extends far enough back so that, when the thigh is flexed, there is no possibility for the head to slip from beneath the roof. It conforms more to the actual depth of the old acetabulum and has an actual downward sloping roof which holds the head encased, so that redislocation is impossible; and above all it utilizes a flap of bone which has its original attachment, and consequently retains its blood supply and therefore is not absorbed.

Fig. 6-A

Case 1. February 24, 1939. Congenital dislocation of the hip in a boy, aged thirteen. The acetabulum is obliterated.

Fig. 6-B

Case 1. Roentgenogram taken March 18, 1939, shows the shelf the day following the operation. Note the length of the bone roof and the wedge above the head of the femur.

This procedure necessitates the preparation of two surgical fields with two incisions, but with an experienced surgical staff the operation can be performed quite rapidly, approximating the time required for other types of shelf operations, and the procedure does not produce any appreciable amount of shock.

CASE REPORTS

Case 1. R. O., a male, aged thirteen, reported to the office on February 23, 1939, complaining of pain, following extensive use of the limb, and gradually increasing shortening. There was no history of previous treatment. Examination disclosed a marked limp, noticeable bulging of the gluteal fold, and the presence of the Trendelenburg sign. Measurement revealed shortening of three inches. Roentgenographic examination showed marked displacement of the head of the femur without any evidence of a secondary socket (Fig. 6-A). The primary acetabulum was entirely obliterated. The diagnosis of congenital dislocation of the hip was made. Skeletal traction was applied for two weeks; then a shelf operation was done (Fig. 6-B). After three months in the original

cast a short hip spica was used and full weight-bearing was allowed. Examination fifteen months following the operation disclosed three inches of shortening, a painless, stable hip, strong gluteal muscles, excellent hip excursion with abduction of about 20 degrees (Figs. 6-C and 6-D).

FIG. 6-C

Case 1. Roentgenogram taken May 19, 1941, shows the end result of the shelf operation two years and two months following the operation.

FIG. 6-D

Case 1. May 19, 1941. Hip movements are free. Note the range of abduction.

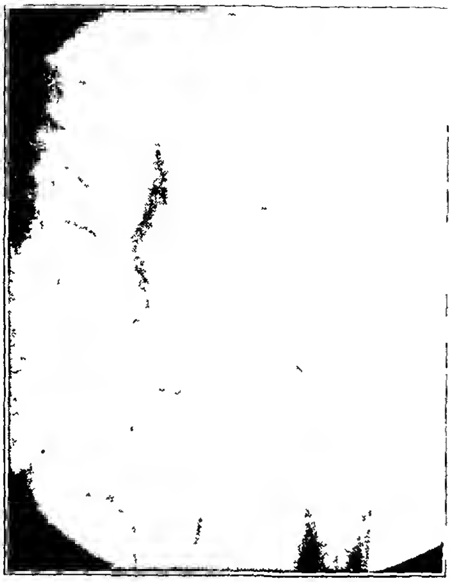

FIG. 7-A

Case 2. February 28, 1939. Congenital dislocation, defective acetabulum with marked upper displacement.

CASE 2. C. H., a male, aged ten, was seen in the office February 17, 1939. He had a congenital dislocation of the hip which had been treated by closed reduction when he was three years of age. Examination revealed a marked limp, the presence of the Trendelenburg sign, and three inches of shortening (Fig. 7-A). He complained of some pain on exertion. On February 20, 1939, skeletal traction was applied, and on March 7, 1939, a shelf operation was done. A spica cast was worn for three months, and a walking short spica for one month. On September 6, 1940, he had a painless, stable hip, one and one-half inches of shortening, flexion to 90 degrees, normal extension, and abduction to 25 degrees (Fig. 7-B).

CASE 3. C. T., a female, aged eight, had an unsuccessful closed reduction for a congenital dislocation of the hip on December 20, 1937. On March 12, 1939, she was admitted to the Shriners' Hospital for Crippled Children (Fig. 8-A) and traction was applied for two weeks. A shelf operation was performed on March 27, 1939. At present the patient walks with a scarcely perceptible limp, and has one-half inch of shortening, a stable hip, free range of motion, and no pain (Fig. 8-B).

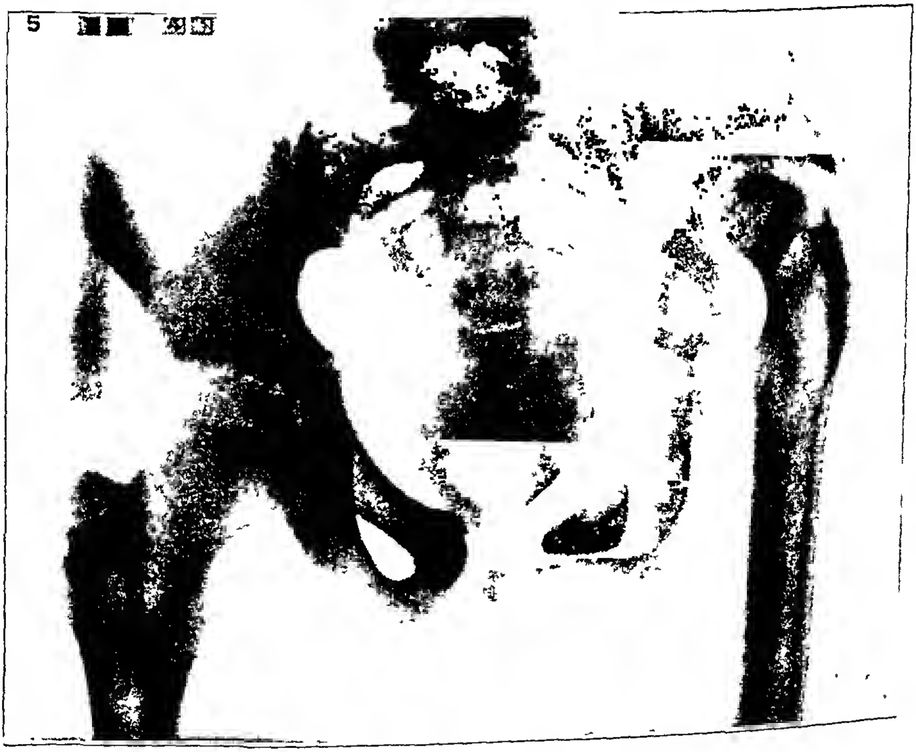

FIG. 7-B

Case 2. Roentgenogram, May 16, 1941, shows end result two years and two months following the shelf operation. The hip is stable and the function is good.

CASE 4. L. P., a male, aged fourteen, had a bilateral congenital dislocation of the hip. An unsuccessful attempt at reduction of the hip was made on January 4, 1937.

FIG. 8-A

Case 3. Roentgenogram, March 10, 1939, shows congenital dislocation of the hip, defective acetabulum, and lateral upward luxation.

FIG. 8-B

Case 3. Roentgenogram, June 12, 1941, shows end result two years and three months following shelf operation. Excellent stability and function.

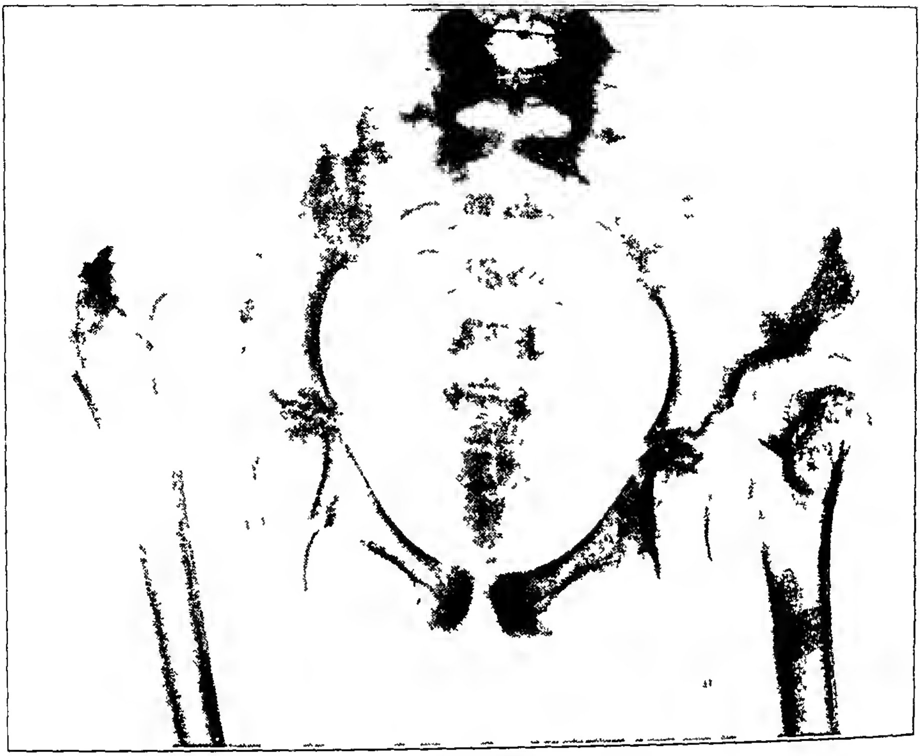

FIG. 9-A

Case 4. Roentgenogram, August 25, 1939, shows bilater
tion of the hip, marked upward dislocation of the right hip, and

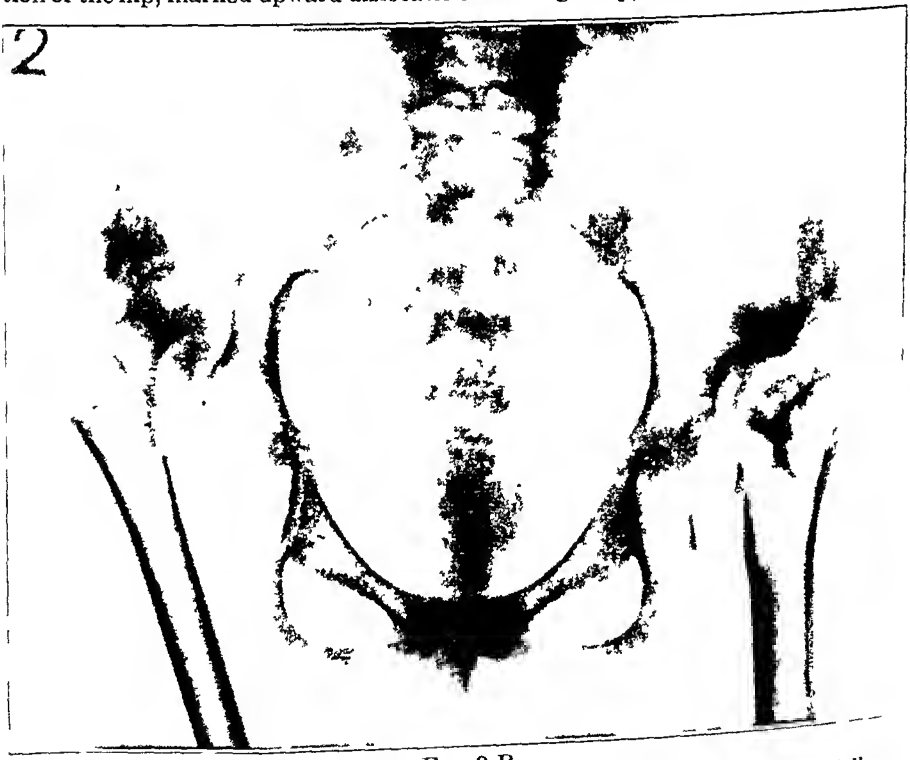

FIG. 9-B

Case 4. Roentgenogram, February 23, 1940, shows end result five months following shelf operation There is free motion, and the stability and function are good.

A shelf operation of the left hip on March 24, 1937, resulted in stability and a fair range of motion. He was admitted to the Shriners' Hospital for Crippled Children on May 13, 1938, for treatment of the right hip, because of pain and instability. The conventional type of shelf operation was done. The shelf was later absorbed and recurrence of the luxation was noted in December 1938. On September 18, 1939, the new type of operation was performed, which resulted in a solid shelf and a clinically stable hip with a good range of motion (Figs. 9-A and 9-B).

CASE 5. M. P., a female, aged eight, was admitted to the Shriners' Hospital for Crippled Children on March 15, 1938, with a congenital dislocation of the left hip. Closed reduction was done March 23, 1938. She was readmitted, May 25, 1939, because of redislocation. The head of the femur was dislocated high above the acetabulum, and the socket was found to be very shallow and defective. A shelf operation was performed, June 14, 1939, and weight-bearing was permitted in two months. The shelf was found to be nearly completely absorbed on December 29, 1939. This is the only failure in the series of nine cases.

CASE 6. F. D., a female, aged fifteen, had been treated in the Shriners' Hospital for Crippled Children for anterior poliomyelitis since 1930. Most of the work had been confined to the extremities on which various stabilizing procedures had been done. The left hip was defective and was displaced upward and posteriorly. A shelf operation was performed, August 16, 1939. One year following the operation the muscle power had improved, motion was free in all directions, roentgenograms revealed a good shelf, and clinically the hip was stable.

CASE 7. C. T., a female, aged eight, had a congenital dislocation of the right hip, for which a closed reduction was done on December 20, 1937. Examination in August 1938, showed a redislocation with one and one-half inches of shortening. Because of the deficiency of the acetabular rim, a shelf operation was performed, March 27, 1939. The new socket formed slowly and some absorption of the shelf resulted, due to a partial break in the graft at its base at the time of operation. The final result was a stable hip, with free range of movement, one inch of shortening, and a scarcely perceptible limp.

CASE 8. E. Z., a female, aged nine, had a bilateral congenital dislocation of the hip. Closed reduction was performed, February 22, 1932. The left hip remained stable, but the right hip redislocated. A second closed reduction was done on the right hip, April 17, 1934, following which the hip gradually luxated again. The acetabulum was very shallow, and the acetabular rim defective. The girl was followed in the Out-Patient Clinic until June 1940. Because of two inches of shortening, marked limp, and pain, she was admitted for a shelf operation. When last seen, December 12, 1940, the hip was stable, the Trendelenburg sign was absent, there was one and one-quarter inches of shortening, and the hip excursion was fairly free.

CASE 9. D. R., a female, aged ten, was first seen in the Clinic of the Shriners' Hospital for Crippled Children on October 20, 1931, when a diagnosis of congenital dislocation of the right hip was made. Closed reduction was done on October 28, 1931, and when the patient was discharged the hip was in the socket; but in 1937 it was found to be redislocated. Because of limp, pain, and shortening, she was readmitted and operated upon on January 20, 1941. The patient has a stable hip, the Trendelenburg sign is absent, and the roentgenograms show that a good shelf has been formed.

SUMMARY

The operative technique described for the stabilization of the irreducible hip in older children and adults, provides a stable socket from which the hip cannot be dislocated, and utilizes a bone plastic flap that remains attached to the ilium and retains its blood supply.

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RETROLUNAR DISLOCATION OF THE CAPITATE WITH FRACTURE OR SUBLUXATION OF THE NAVICULAR BONE

BY EDWIN FRENCH CAVE, M.D., BOSTON, MASSACHUSETTS

From the Fracture Clinic of the Massachusetts General Hospital, Boston

Dislocation of the capitate bone, with fracture or subluxation of the navicular, has been third in frequency of occurrence in the series of carpal bone injuries at the Massachusetts General Hospital. It is, however, far outnumbered by fractures of the navicular bone, and dislocations of the lunate. All fractures and dislocations of the carpus represent about 2 per cent. of bone injuries in this Clinic.

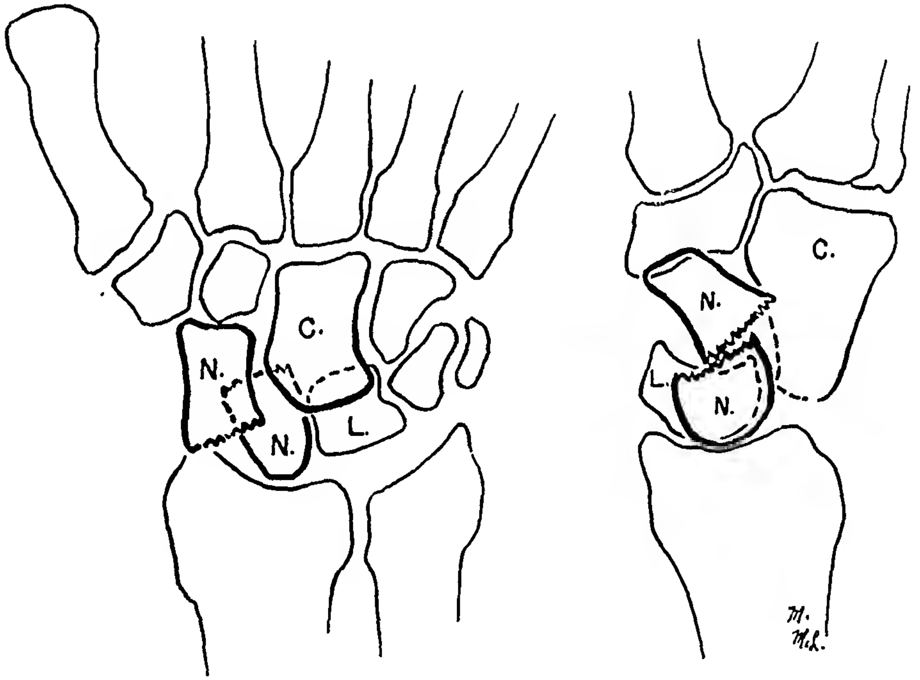

FIG. 1

Tracings of fracture of the navicular (*N*) and retrolunar dislocation of the capitate (*C*).

MECHANISM

Retrolunar dislocation of the capitate (os magnum), sometimes referred to as transcarpal dislocation, is produced by a blow which suddenly forces the hand into dorsiflexion. The commonest type of injury is a fall on the outstretched hand. The force may be transmitted through the third metacarpal, or may be received directly by the distal portion of the capitate. The dislocation of the capitate must be accompanied by a fracture of the navicular bone, or rotation luxation of this bone. Usually great force is required to bring about such an injury. When the injury occurs, the ligamentous structures between the lunate and the capitate are ruptured, and the blood supply is interrupted. The

lunate retains its normal relationship to the radius, or may be tilted slightly toward the palmar surface; the capitate is displaced dorsally to the lunate bone. At the same time, because of the shortening of the distance between the radius and the second row of the carpus, the navicular either must be fractured transversally (Fig. 1), or must rotate through its long axis (Fig. 2). If the navicular has been fractured, the distal portion of the bone moves dorsally and upward with the displaced capitate, while the proximal fragment continues to maintain its normal relationship to the radius. More frequently the navicular may be subluxated rather than fractured, and rarely is it completely dislocated.

DIAGNOSIS

As with all other carpal injuries, the diagnosis is based entirely upon the roentgenograms and thorough knowledge of the anatomical relationship of the carpus is required to interpret them. Standard exposures should be made (Fig. 3). The writer has frequently seen the diagnosis of retrolunar dislocation of the capitate confused with dislocation of the lunate bone, as occurred in the following case:

Case 1. R. W. (No. 318839), aged twenty, male, was admitted January 20, 1932. Two months before, he had fallen on the dorsiflexed hand while playing football. He had had no treatment. Roentgenograms on admission showed what was interpreted as a dislocation of the lunate. The lunate bone was excised through an anterior incision. As original roentgenograms had indicated, however, the correct diagnosis was retrolunar dislocation of the capitate (Figs. 4-A, 4-B, and 4-C). One year later there was marked limitation of motion, particularly in palmar flexion, but no pain.

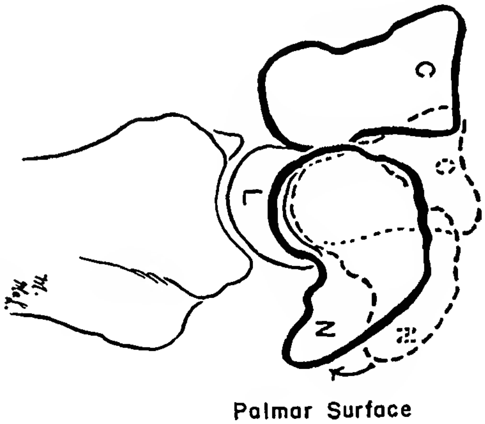

Fig. 2

The capitate (C) is displaced dorsally to the lunate (L) while the navicular (N) has rotated so that the tubercle or distal portion points toward the palm.

TREATMENT

The Treatment of Dorsal Dislocation of the Capitate and Rotation Luxation of the Navicular.

With this injury, immediate closed reduction by traction in hyperextension, then in extension, and finally in flexion is indicated. The earlier the manoeuvre is attempted after injury, the more likely it is to succeed. If it is delayed beyond a few days, open reduction may be necessary, and if many days or weeks have passed, even operation may fail. If closed reduction is successful, immobilization with an anterior splint for ten days is sufficient.

CASE 2. W. S. (No. 333357), aged thirty-seven, male, was admitted to the Emergency Ward November 12, 1933, with a retrolunar dislocation of the capitate, rotation luxation of the navicular, fracture of the head of the radius, and fracture of the ulnar styloid, following an automobile accident. Reduction had been attempted under ether anaesthesia, but had failed (Figs. 5-A and 5-B). On November 17, an incision was made over the dorsal aspect of the wrist. The capitate was found to be displaced backward on the lunate, and the navicular was rotated, so that it occupied partially the normal position of the capitate. The capitate was reduced to its normal relationship with the lunate and this brought the navicular into normal position. On November 25, the patient was discharged from the Hospital, wearing a plaster splint. All apparatus was discarded at the end of two weeks. One year later the patient was working at his old job. He had no pain; motions were three-quarters normal, and still improving. Roentgenograms show normal relationship of bones (Figs. 5-C and 5-D).

Treatment of Retrolunar Dislocation of the Capitate with Fracture of the Navicular.

When in addition to the dislocation of the capitate, there is a fracture of the navicular, such fracture may reduce spontaneously as the displaced

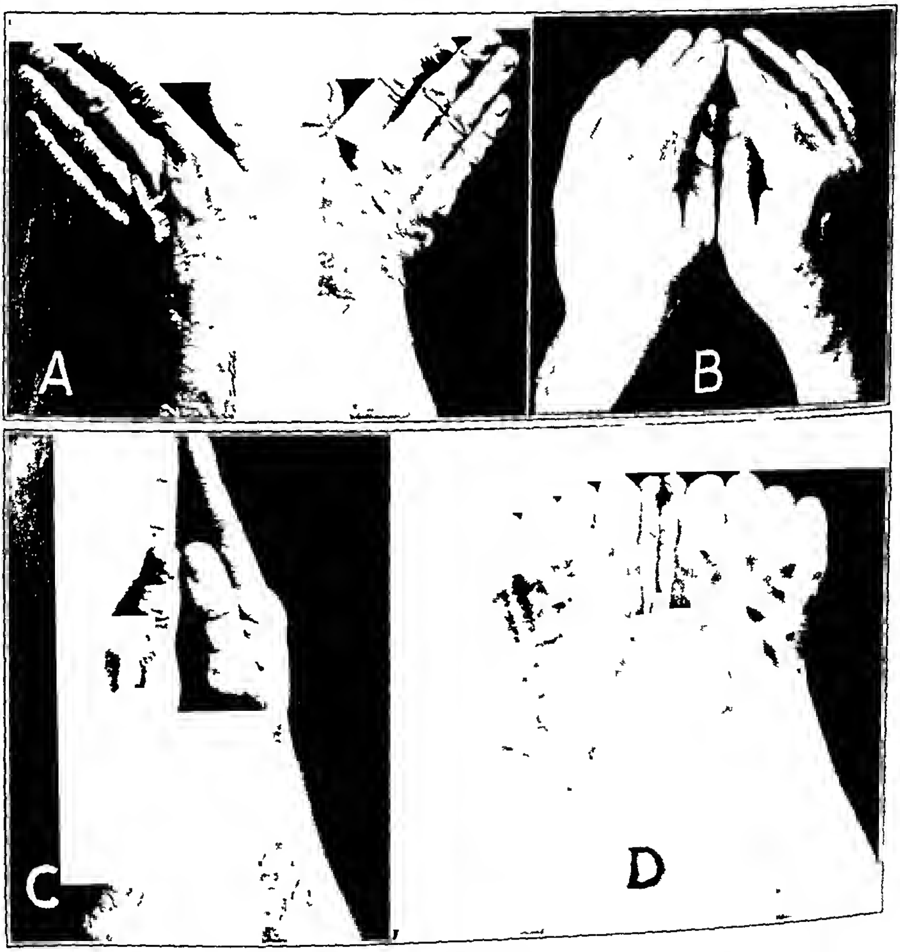

FIG. 3

Standard exposures for roentgenography of the carpus. (*A, B, and C reproduced by courtesy of J. B. Lippincott Company, and the American Medical Association.*)

FIG. 4-A

FIG. 4-B

Case 1. R. W. (No. 318839). Figs. 4-A and 4-B show a typical retrolunar dislocation of the capitate.

FIG. 4-C

Case 1. R. W. (No. 318839). End result of retrolunar dislocation of the capitate. Lunate has been removed; navicular has been displaced forward into the palm; capitate is articulating with the radius. (Open reduction of dislocated capitate with restoration of the navicular and lunate to normal position would have been treatment of choice.) (*Courtesy of J. B. Lippincott Company.*)

capitate is restored to its normal position; but if accurate reposition of the navicular fragment is not obtained, open operation should be done, and the fragments of the navicular realigned, and held with a dowel graft.

The following two cases illustrate this point: In the first case (McK.) the fractured navicular was treated with closed reduction of the dislocation, and later a dowel graft to the navicular. The second (B. C.) was

treated by closed reduction only. Note that union of the navicular was produced in the first case, and that non-union of this bone resulted in the second. Otherwise the cases are very similar.

Case 3. McK. (No. 134433), aged seventeen, male, was admitted June 15, 1938, one-half hour after he fell from a moving truck, landing on the dorsiflexed left wrist. Roentgenograms revealed a retrolunar dislocation of the capitate, and fracture of the navicular, with dorsal and upward displacement of the distal fragment of the navicular (Fig. 6-A). Under general anaesthesia, fluoroscopic reduction of the dislocation of the capitate and fracture of the navicular was done. Postreduction roentgenograms showed unsatisfactory position of the navicular fragments (Fig. 6-B). On

Fig. 5-A

Fig. 5-B

Case 2. W. S. (No. 333357). Figs. 5-A and 5-B show in anteroposterior and lateral views a recent retrolunar dislocation of the capitate and rotation dislocation of the navicular.

Fig. 5-C

Fig. 5-D

Case 2. W. S. (No. 333357). Figs. 5-C and 5-D show result after open operation.

FIG. 6-A

Case 3. McK. (No. 134433). Anteroposterior view showing fracture of the navicular with displacement; and lateral view showing retrolunar dislocation of the capitate.

June 23, 1938, under general anaesthesia, a bone graft from the tibia was placed in the left navicular bone. After postoperative immobilization for four months, roentgenograms, taken October 31, 1938, showed bony union of the navicular with the graft in place. On March 6, 1940, patient was symptom free, and working at a printing press. There was a slight thickening over the dorsum of the navicular. There was dorsiflexion on the right of 45 degrees, left, 45 degrees; palmar flexion on the right of 25 degrees, left, 30 degrees; ulnar deviation on the right of 20 degrees, left, 10 degrees; radial deviation on the right of 20 degrees, left, 5 degrees; pronation on the right of 90 degrees, left, 90 degrees; supination on the right of 90 degrees, left, 90 degrees. Grip was equal on both sides. Roentgenograms showed complete bony union (Fig. 6-C).

FIG. 6-B

Case 3. McK. (No. 134433). Anteroposterior view showing incomplete reduction of the fractured navicular.

CASE 4. B. C. (No. 127846), aged eighteen, male, was admitted May 10, 1938. Five days before, the patient had fallen backward on the dorsiflexed left wrist. A splint was applied. Roentgenograms revealed retrolunar dislocation of the capitate; fracture of the cuneiform and navicular, with displacement (Figs. 7-A and 7-B). The distal fragment of the navicular was displaced dorsally and upward. Under general anaesthesia, fluoroscopic reduction of the dislocation and fracture was made. Postoperative immobilization was continued for four months, when roentgenograms showed satisfactory reduction of the dislocation, but non-union of the navicular fracture. On March 18, 1940, twenty-two months after injury, there was a slight thickening of the dorsum of

FIG. 6-C

Case 3. McK. (No. 134433) Anteroposterior and oblique views three months after operation, showing bony union of the navicular fracture with the graft in place.

the wrist. There was dorsiflexion on the right of 80 degrees, left, 70 degrees, palmar flexion on the right of 65 degrees, left, 10 degrees; ulnar deviation on the right of 20 degrees, left, 20 degrees, radial deviation on the right of 25 degrees, left, 15 degrees, pronation on the right of 90 degrees, left, 90 degrees, supination on the right of 90 degrees, left, 90 degrees Grip was equal on both sides. This was a fairly good clinical result at this time, but, be-

FIG. 7-A

FIG. 7-B

Case 4. B. C. (No. 127846). Fig. 7-A: Lateral view showing retrolunar dislocation of the capitate.

Fig. 7-B: Anteroposterior view showing fracture of the navicular with displacement.

cause of non-union of the navicular, this bone is potentially a source of trouble, and will probably cause pain in the future. Operation and bone graft to the navicular was advised.

The graft operation must be done within a few days, otherwise one may find it impossible to realign satisfactorily the navicular fragments, even though the dislocated capitate may have been reduced. If it is necessary to reduce the capitate by open operation as well as to graft the navicular, two incisions—one a mid-dorsal, and the other a curved radial incision—should be employed (Figs. 8 and 9).

Postoperative fixation in plaster in this type of case should be carried out until union of the navicular is complete,—that is, usually from six to twelve weeks.

The Treatment of Old Retrolunar Dislocation of the Capitate, with or without Fracture of the Navicular Bone.

The neglected case probably cannot be satisfactorily treated by attempting to restore normal position of the carpal bones. If this fails, one must choose between (1) excision of the lunate and navicular bones and (2) wrist fusion. Excision of these two bones may result in improved motion, and less pain in the wrist, but will produce a weakened wrist, probably necessitating the use of external support for heavy work. Wrist fu-

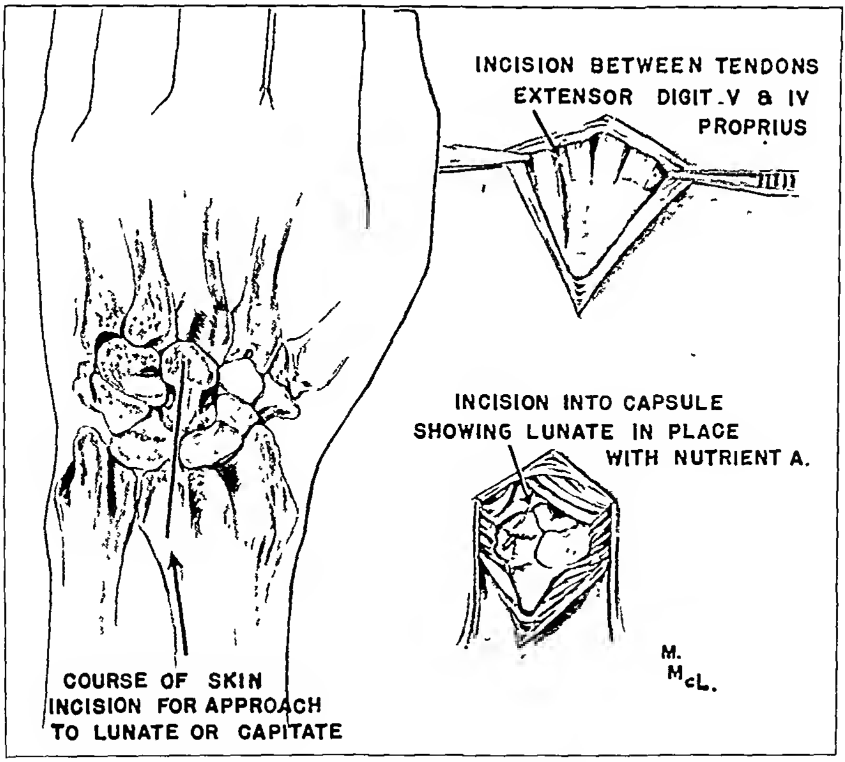

Fig. 8
Dorsal approach to carpus.

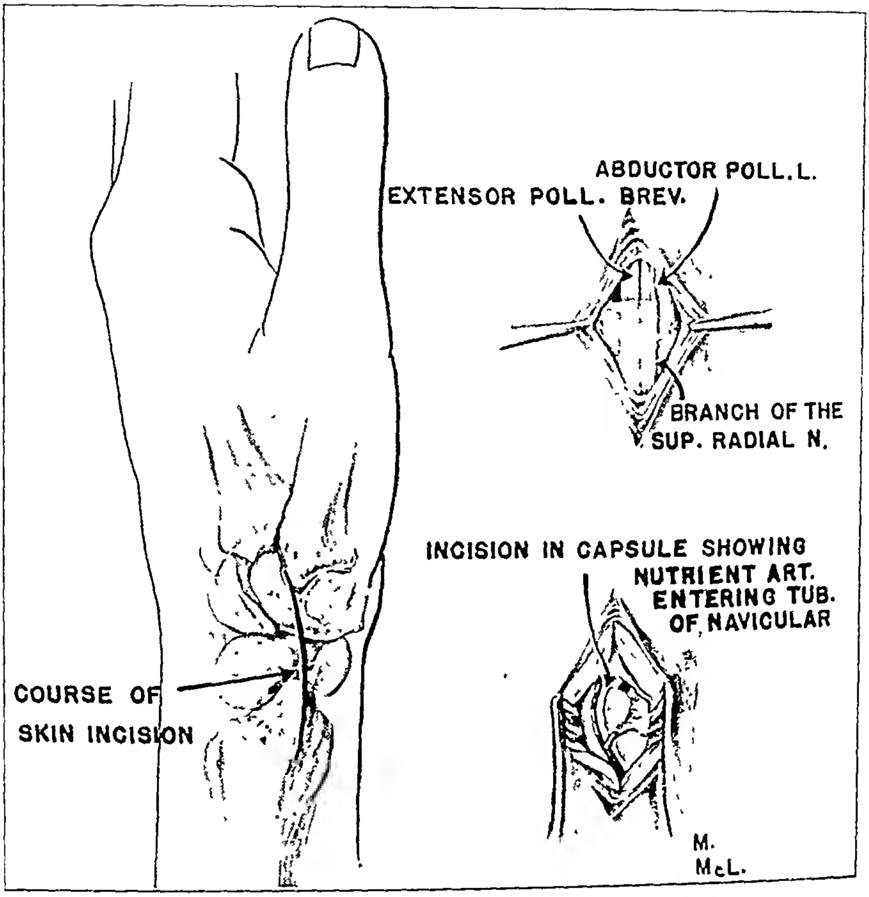

FIG. 9

Radial approach to the navicular bone. (*Courtesy of the American Medical Association.*)

sion is the alternative to the excision operation; this will produce a strong wrist, and while motion in dorsiflexion and palmar flexion will be eliminated, pronation and supination can be maintained, if the fusion is carried out only between the radius and the carpus.

CASE 5. A. J. (No. 341976), aged thirty-one, male, was admitted to the Emergency Ward on September 21, 1934, with multiple contusions and abrasions of the arm and leg, fracture of the ulnar styloid, and chip fracture of the lesser trochanter, following a motor-cycle accident. His left arm was put in a plaster splint. The patient continued to have trouble with his wrist, which was swollen, painful, and limited in motion. Two and a half months after injury, further roentgenograms revealed retrolunar dislocation of the capitate and fracture of the carpal navicular, with posterior displacement of the proximal fragment of the navicular (Fig. 10-A). A dorsal incision was made in the mid-line. It was impossible to reduce the fractured navicular. The capitate could be reduced to its normal relationship with the lunate, but it would not stay in position. Because of the fact that the injury was old, and scar tissue extensive, it was decided to remove the lunate and navicular bones. The patient was discharged from the hospital two weeks later, wearing an anterior plaster splint (Fig. 10-B). There was much less pain, and more motion in the wrist, but there was still considerable weakness. The patient was, therefore, fitted with a leather wristlet. One year later, the patient was working in a machine shop. There was less pain, and the wrist had improved in strength, but was still weaker than

FIG 10-A

Case 5. A J (No 341976). Anteroposterior and lateral views of the hand two and one-half months after injury, showing retrolunar dislocation of the capitate, and fracture of the mid-position of the navicular with upward and backward displacement of the proximal fragment All of the bones of the hand show marked atrophy

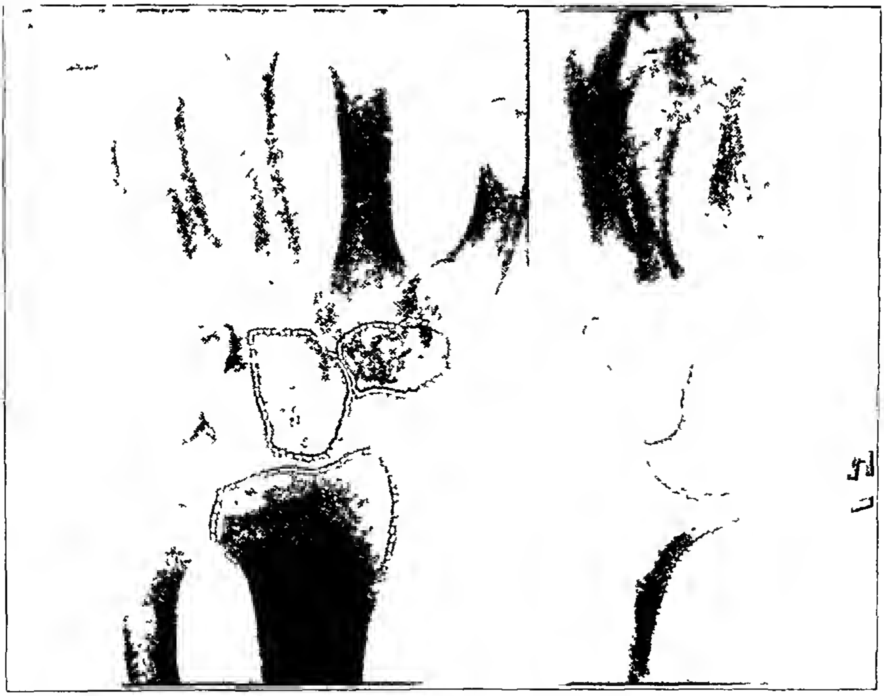

FIG 10-B

Case 5 A J (No 341976) Anteroposterior and lateral views after navicular and lunate have been removed The capitate is still dorsally displaced

the opposite one. There was slight radial deviation. The patient was wearing his wristlet while at work.

CONCLUSIONS

1. Retrolunar dislocation of the capitate bone with fracture or with subluxation of the navicular is one type of carpal injury.

2. Reduction of the dislocation by manipulation can be accomplished if done early. If this is not successful, open reduction must be carried out.

3. If there is an associated navicular fracture, and satisfactory alignment of the fragments is not obtained by manipulation, open reduction and insertion of a bone graft should be done.

4. In neglected cases of this type of injury, the choice of treatment rests between excision of the first row of the carpus and wrist fusion.

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THE CONSERVATIVE AND OPERATIVE TREATMENT OF FRACTURES OF THE CARPAL SCAPHOID (NAVICULAR) *

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Because of the well-deserved reputation for prolonged disability fractures of the carpal navicular have obtained considerable prominence in current medical literature. Another reason for the interest in this problem is the variety of operative methods which may be used in the treatment of fractures of the navicular which fail to unite. The purpose of this presentation is twofold: to show the end results of a group of acute fractures which were treated conservatively by a method previously described [24], and to evaluate the various operative measures which have been employed in the treatment of non-union.

TABLE I

AGE OF PATIENTS

	No
10–19 years	7
20–29 years	18
30–39 years	15
40–49 years	6
50–59 years	4
Total	50

In 1934 the authors described the conservative treatment of sixteen cases of recent fracture of the carpal navicular, twelve of which resulted in bony union. During the past eight years fifty additional patients, with all types of fractures, have been treated. A tabulation of this series of fifty cases appears to form a satisfactory basis upon which to draw conclusions. The preponderance of males to females—forty-seven to three—doubtless results from the large proportion of industrial injuries. The maximum incidence occurred during the third and fourth decades of life, before attritional or senile changes appear (Table I). The duration of these fractures (Table II) permitted about one-half of them to be treated

TABLE II

DURATION OF FRACTURE

Acute (up to 14 days)	19
Subacute (2 weeks to 6 months)	17
Old ununited fracture with reinjury	7
Old ununited fracture without reinjury	7
Total	50

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, New Orleans, Louisiana, on January 15, 1941.

TABLE III

TYPE OF FRACTURE SHOWN IN ROENTGENOGRAMS

Transverse through body without displacement	37
Transverse through body with displacement	3
Comminuted	6
Type not specified	4
Total	50

conservatively. The high incidence of fractures through the waist of the navicular (Table III) allows a considerable uniformity in their treatment. Associated injuries of the carpus, of which a dislocation of the lunate bone is the most common (Table IV), frequently alter the type of treatment required. Following the reduction of a ventral dislocation of the lunate bone, for example, it is advisable to assure prevention of a recurrence of the dislocation by immobilization of the wrist in some ventral flexion, rather than in the preferred position for navicular fractures.

TABLE IV

ASSOCIATED INJURIES IN THE WRIST

Dislocation of the lunate bone	6
Fracture of the lower end of the radius	3
Fracture of other carpal bone	1
Fracture of metacarpal bone	1
Total	11

The choice of treatment to be employed in the individual case (Table V) will be discussed later in this report. In Tables VI and VII, the end results in the entire series have been reported with regard to the occurrence of osseous union. Obviously, from this standpoint, the cases of excision of one or both fragments have no significance. The functional end result, as indicated by the ability to return to work, is shown in Table VIII.

Success in the treatment of the fractured carpal navicular depends upon an early recognition of the fracture and a complete and prolonged immobilization of the fragments. Of the various factors concerned in

TABLE V

TYPE OF TREATMENT

Conservative (cast in radial-dorsal flexion)		25
Operative		
Drilling operation	10	
Drilling and bone graft	8	
Excision of proximal fragment	6	
Excision of entire scaphoid	1	
Open reduction of fracture	2	27
Total		52*

* This figure includes one patient who had had conservative treatment with resultant non-union, and later a drilling and bone-graft operation, and a second patient who had had a drilling operation without union, and later an operation for the excision of the proximal fragment of the scaphoid.

TABLE VI

RESULTS OF CONSERVATIVE TREATMENT

In recent fractures		
Osseous union	20	
Non-union	1	
	—	21
In old ununited fractures with recent reinjury		
Osseous union	0	
Persistence of non-union (with subsidence of recent symptoms)	4	
	—	4
		—
Total		25

TABLE VII

RESULTS OF DRILLING AND BONE-GRAFT OPERATIONS

Drilling operation		
Osseous union	5	
Doubtful union	2	
Non-union	2	
Result unknown	1	
	—	10
Bone graft and drilling operation		
Osseous union	6	
Non-union	1	
Result unknown	1	
	—	8
		—
Total		18

the development of non-union, considerable importance must be attached to the blood supply of this bone. The chief artery enters through the tubercle, at the distal end of the bone, and one or more additional arterial foramina are found along various points of the body of the bone Obletz and Halbstein found that the proximal half of the navicular had no foramina, or only a single foramen, in about one-third of the specimens studied Aseptic necrosis is seen most frequently in small proximal fragments, and in such cases is a formidable obstacle to union The absence of periosteum from most of the surfaces of the navicular (those covered with articular cartilage) is probably responsible for a retarded rate of healing, as compared with that of the long bones [15].

A rational approach to the prevention and treatment of non-union in any bone should be based upon a study of the microscopic changes

TABLE VIII

RETURN TO WORK

Returned to former type of work	36
Returned to lighter type of work	2
Did not return to work	1
Still under treatment	1
Result unknown	10
	—
Total	50

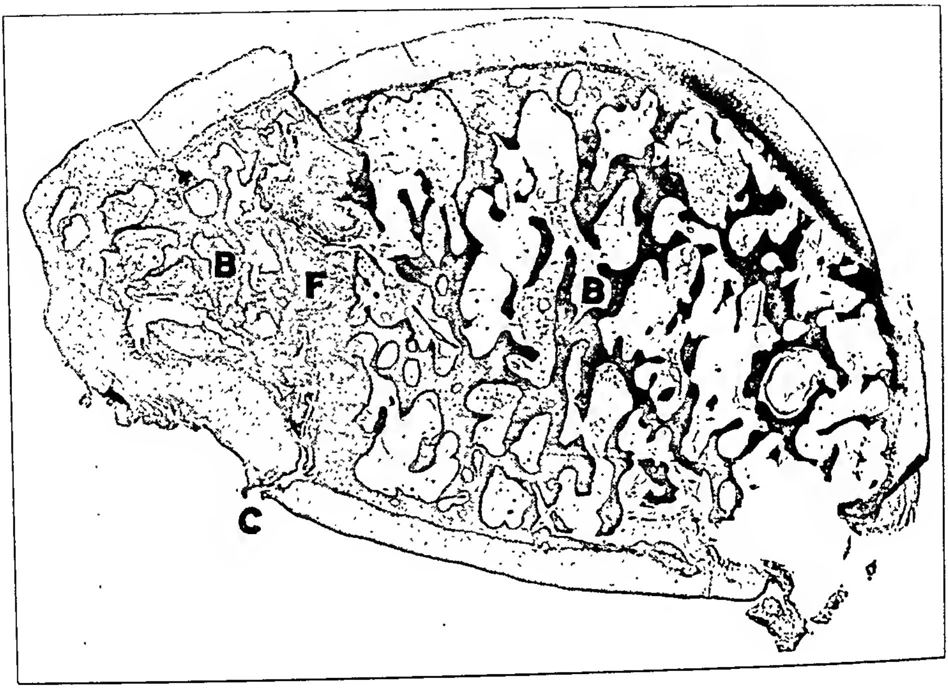

FIG. 1

Photomicrograph ($\times 7$) of proximal fragment of the navicular excised seven months after injury. The section shows an ununited fracture near one end of the excised fragment. Note the absence of callus, and the failure of the cartilage to heal. C = Cleft in the cartilage; F = Fibrosis along the line of fracture; and B = Cancellous bone.

which take place at the site of the lesion. The common observation in the roentgenograms of a progressive absorption of bone along the line of fracture has its counterpart in the picture shown by microscopic sections. Sections of five naviculars which were excised surgically show a character-

FIG. 2-A

A. R. Two days after injury the fracture cannot be seen.

FIG. 2-B

A. R. Five weeks after injury the fracture line is visible.

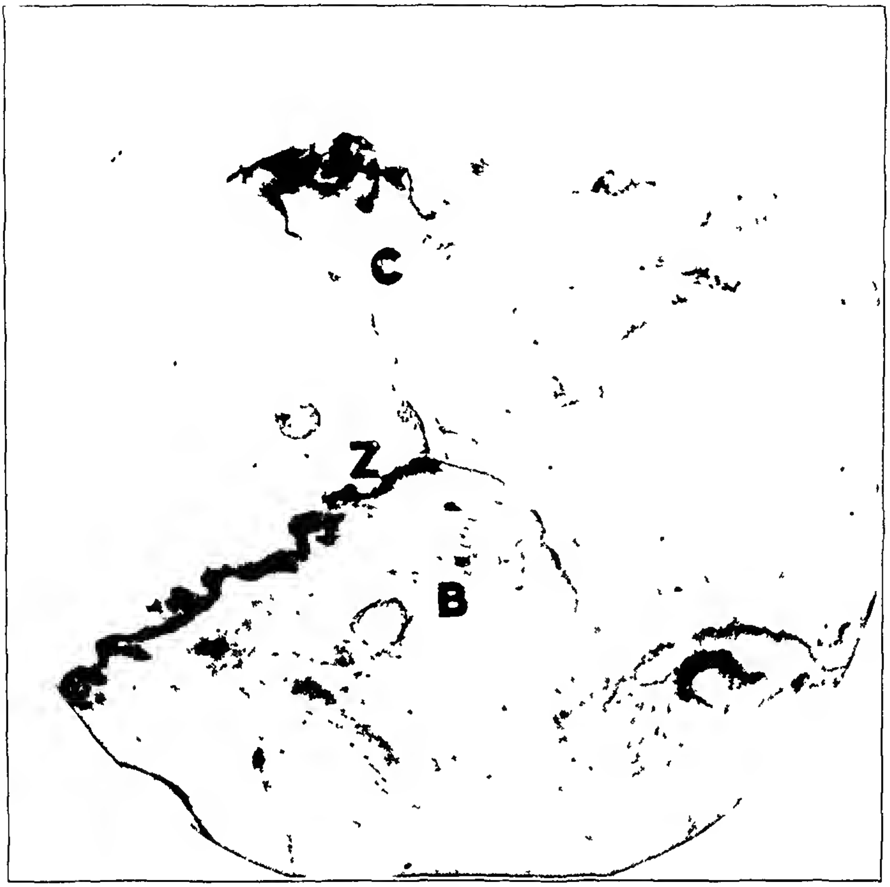

Fig 3

Photomicrograph (× 100) of cleft in the cartilage of the proximal fragment of the navicular excised one year after injury. This view does not include the line of fracture through the bone. Note complete failure of the cartilage to heal.

C=Cleft in the cartilage, *B*=Subchondral bone; and *Z*=Zone of provisional calcification.

istic fusiform area of absorption which occurs along the line of fracture of those naviculars which have not been adequately immobilized (Fig. 1). The bone disappears and is replaced by fibrous connective tissue near the center of the fracture. This condition is sometimes referred to as cystic degeneration, although no true cyst of the bone occurs. Even if considerable absorption of this type is present, the insertion of a bone graft, or prolonged immobilization, often leads to a restoration of the normal appearance of the bone. Microscopic studies of these specimens (Fig. 3), and of other examples of injury to articular cartilage, have shown the complete inability of hyaline cartilage to regenerate [13]. The most that can be hoped for is a filling of the defect in the cartilage with connective tissue which slowly takes on some of the characteristics of fibrocartilage. It may be this failure of regeneration of cartilage which accounts for the persistence of pain in the wrist after osseous union of the fractured navicular has occurred.

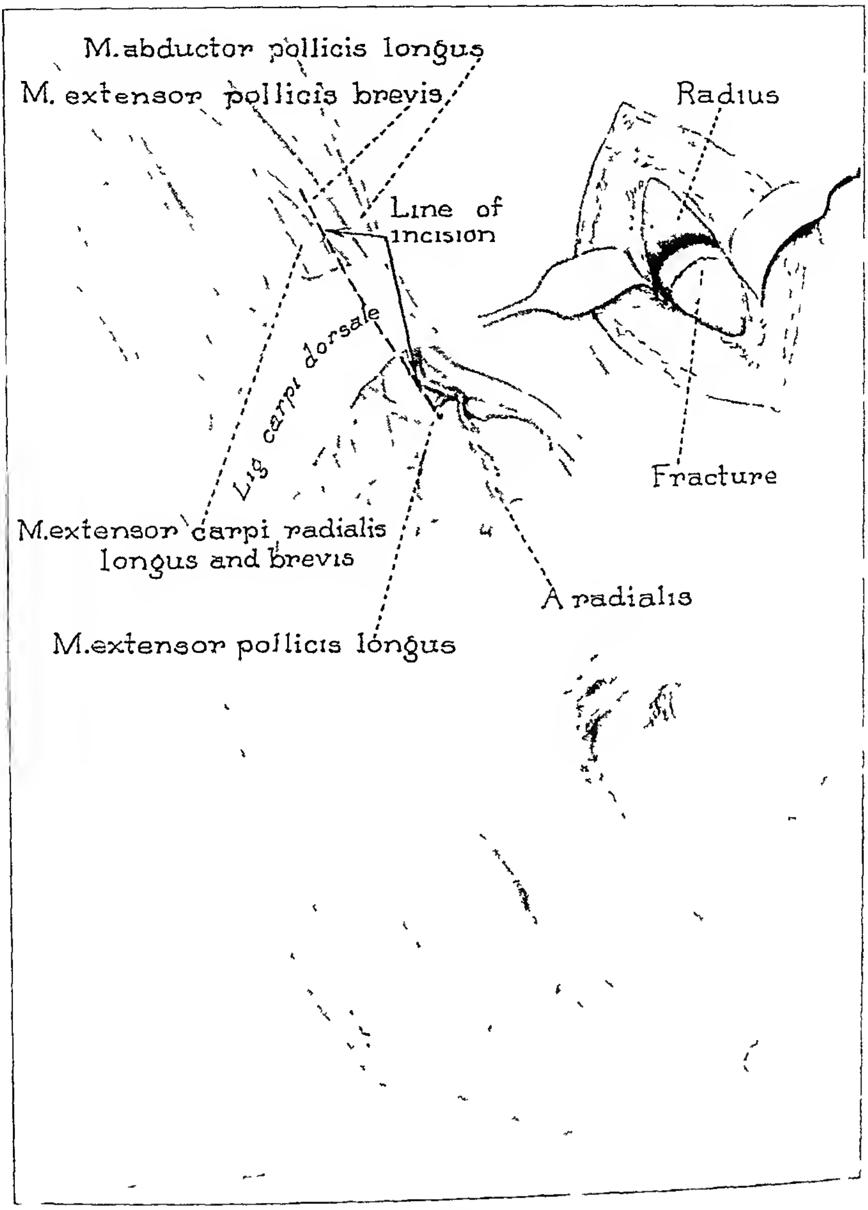

FIG. 4

Operative exposure of the navicular.

The most important causes of non-union in these fractures are ineffectual or insufficiently prolonged immobilization and, all too often, failure to make a diagnosis within the first two weeks after injury. The history of a blow on the palm of the hand, with the wrist in dorsiflexion, followed by immediate pain over the radial border of the wrist, should suggest the presence of a fracture of the navicular. If a fracture has occurred, there is usually tenderness, and occasionally fullness, over the anatomical snuffbox and on the dorsal and ventral aspects of the navicular. An important clinical sign is the occurrence of pain in the navicular region when percussion is made on the tip of the abducted thumb

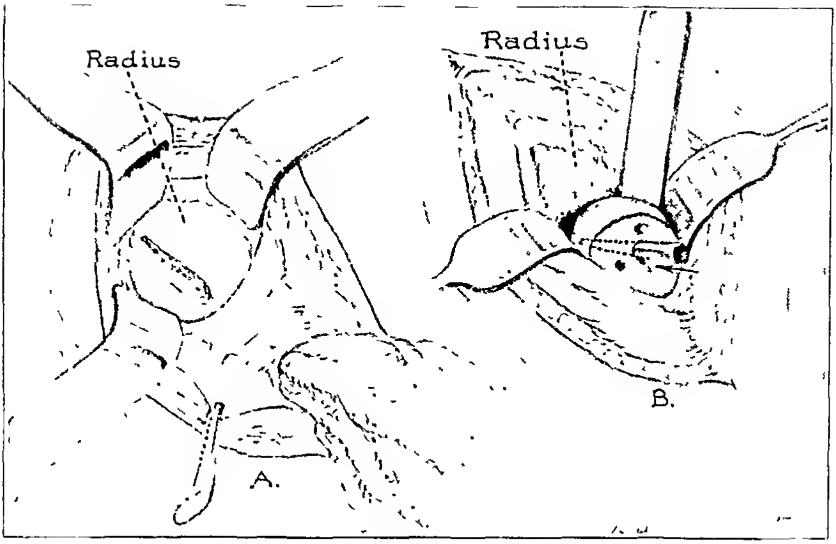

FIG. 5

Removal of the bone graft from the radius and its insertion into the navicular which has been drilled.

or over the distal end of the second metacarpal bone. Forced ulnar flexion of the wrist is usually painful.

Although roentgenographic examination is essential, and antero-posterior and oblique views should be taken with the wrist in full ulnar flexion, it must be emphasized that a negative roentgenogram immediately after injury does not eliminate the possibility of a fracture. If the clinical signs point to a navicular fracture, the patient should be treated as having such, and the roentgenographic examination should be repeated at the end of three weeks, at which time absorption of bone will have occurred along the line of fracture, and the roentgenogram will give the true diagnosis. Two cases in our series illustrate this point (Figs. 2-A and 2-B). It is most important that the treatment begin immediately after the injury has occurred, even at the risk of immobilizing a wrist in which no fracture is subsequently demonstrated, because the chances of success in conservative treatment rapidly fade with the passage of time between injury and immobilization.

In a consideration of the treatment of fractures of the navicular, their classification should be both anatomical and chronological. The anatomical grouping includes (1) lesions of the body, through the waist, (2) lesions through the proximal pole, (3) lesions of the tubercle, and (4) comminuted fractures. Chronologically they may be grouped as recent—up to two weeks—and old. The term subacute may include the borderline cases. Recent fractures through the body or proximal pole of the navicular should be immobilized by a cast which holds the wrist in full radial flexion and 30 degrees of dorsiflexion, and includes the thumb which is held in full abduction and extension, in the manner previously described by the authors [24]. In the application of the cast including the

FIG. 6-A

L. S. November 1, 1937, five days after injury.

FIG. 6-B

L. S. March 8, 1938, four and one-half months after injury, there is increased density (aseptic necrosis) of the proximal fragment of the navicular.

FIG. 6-C

L. S. October 10, 1940, three years after injury, the fracture is healed following drilling and insertion of the bone graft. Note the equal density of the fragments.

thumb, care must be taken to force the thumb into abduction by pressure on its base, rather than on its tip, because the latter procedure may lead to a slight subluxation of the metacarpophalangeal joint of the thumb. The thumb is released after six weeks, but immobilization of the wrist may be necessary for from three to six months. At the end of ten or twelve weeks, a reinforced leather wrist support, which includes the hand, may be used for the more prolonged immobilization. Fractures of the tubercle of the navicular usually heal after from four to six weeks of immobilization, which need not include the thumb. The existence of marked comminution of the navicular usually precludes a satisfactory functional result with conservative treatment, and may be an indication for the excision of the fragments, which should be done early in order to avoid arthritic changes in the wrist. As previously noted, primary attention must sometimes be paid to associated injuries of the carpus.

In the treatment of less recent cases of fracture, an early decision

regarding the operative procedure to be employed is important in order to shorten the period of disability, and to prevent arthritic changes in the wrist, as evidenced by the sharpening of the styloid process of the radius, which is commonly seen in old ununited fractures of the navicular. In the earlier cases of this series the operation of drilling, introduced by Schnek was used but is now reserved for those naviculars which do not show extensive absorption at the line of fracture. The authors' experience showed that healing was very slow following the drilling operation, and that osseous union could be anticipated in only about one-half of the cases. The unfavorable cases were those in which the roentgenograms showed absorptive changes. Pathological studies have convinced the authors that simple drilling does not sufficiently stimulate osteogenesis. They have, therefore, altered their technique (Figs. 4 and 5) to include the exposure of the site of the fracture, the excision of all fibrous tissue lying between the fragments, multiple drilling through both fragments, and the introduction of one or two bone grafts [1, 20]. The removal of the bone peg from the cortex near the distal end of the radius and its insertion through a hole which enters the distal fragment near the tubercle and penetrates the proximal fragment, does not unduly complicate the operation, and certainly favors union by the addition of osteogenic tissue and the provision of internal fixation of the fragments.

Excision of the proximal ununited fragment of the navicular seems advisable when this fragment is too small to permit the insertion of a bone graft. This operation has also been employed for the occasional patient upon whom a bone graft or drilling operation was unsuccessful. Its use in comminuted fractures has been cited. Although the presence of aseptic necrosis of the proximal fragment would seem to require its excision, the authors have seen the revascularization and osseous union of such a fragment following the insertion of a bone graft (Figs. 6-A, 6-B, and 6-C).

CONCLUSIONS

1. Success in the treatment of fractures of the carpal navicular depends upon the recognition of the fracture within two or three weeks of injury, and upon adequate and prolonged immobilization. Under these favorable conditions osseous union may be anticipated in a very high percentage of cases.

2. Excision of one or both fragments of the navicular is reserved for a limited number of cases, including those showing marked comminution and those in which other measures have failed.

3. From further experience in the operative treatment of non-union, it would seem that the drilling operation has a limited value; and that a procedure is indicated which combines the excision of the interposed fibrous tissue, the drilling of the bone, and the insertion of a bone graft from the radius. This procedure materially reduces the period of necessary immobilization and increases the chances of union.

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AN EVALUATION OF PHYSIOTHERAPY IN THE EARLY TREATMENT OF ANTERIOR POLIOMYELITIS *

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Poliomyelitis exists in endemic form in this country, but few clinics have at their disposal a series of acute cases of the true epidemic form large enough to permit a comparative study of the various therapeutic measures most frequently used. Prior to 1933, it was unusual for a case of poliomyelitis in the acute or subacute stage to be seen at Shriners' Hospital, although patients with the chronic form outnumbered those with any other disease process accepted for treatment. During the year 1935, forty-one recent cases were observed; in 1936, sixty-three cases; in 1937, forty-five cases; and in 1938, eleven cases. During this four-year period, a total of 160 cases (325 involved extremities) were seen, and these have now been followed long enough to state definitely the degree of residual involvement which they show, and therefore to determine the value of the treatment used in each case.

The first group, in 1935, were treated by immobilization in solid plaster until all evidence of muscle tenderness, and muscle and joint pain had disappeared,—usually a period of three to four months. This was followed by immobilization in plaster splints or bivalved plasters with the paralyzed muscles relaxed, and physiotherapy treatments five days each week, in the pool at a temperature of about 95 degrees Fahrenheit. Each treatment lasted about twenty minutes. At the end of nine months, when it was possible to ascertain with some measure of certainty the residual involvement, the results were found to be very disappointing.

It was at this time that the authors learned of the excellent results which had been obtained by Kendall by means of prolonged immobilization, and prolonged rest and protection, and it was decided to give the method a thorough trial should a similar epidemic occur in 1936. It became necessary at about this time to obtain a new physiotherapist, so one trained by Mr. Kendall was secured. The work with the next series of patients was more or less turned over to her as it was felt that, to give this method an impartial trial, the work should be done by some one thoroughly familiar with his ideas and the details of his method of treatment. In order to facilitate the ease of handling these patients and to assure every possible advantage for the patients and for the method at trial, one entire ward was set aside solely for their care. Thirty patients were admitted during the course of a few days and remained for approximately nine months under constant observation. It was the authors' privilege

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, New Orleans, Louisiana, January 14, 1941.

to have a visit from Mr. Kendall during this time to check the methods being employed, to discuss any changes which might be beneficial, and to assure close adherence to his ideas. Much to the authors' surprise, however, the results in that year were no better than in the previous year, and the percentage of patients actually showing improved muscle power, as a result of the new treatment, was no greater.

During the next two years no one single plan of therapy was followed. The patients were treated in various ways, depending on the needs of each individual. No attempt will be made to discuss the details of the various recommended procedures as these have been adequately described by the proponents of each method [1,2,4,5,6,7]. These have varied from prolonged immobilization on the one hand, to intensive physiotherapy, which entirely disregarded immobilization and rest even in the very acute stage and carried all joints through a full range of motion at frequent intervals, on the other. The latter method (Sister Kenny's), originating in Australia, has not been tried in cases supervised by the authors, and as yet has had very little intentional application in this country. Between these two extremes lie those methods which adhere to various periods of early immobilization, accompanied or followed by some form of physiotherapy. The usual and probably the most popular form of physiotherapy used in this country today is the underwater therapy.

An attempt has been made to analyze critically the results in this series of 160 cases without preconceived ideas as to the relative value of any particular form of therapy. The analysis itself is extremely difficult, and it is questionable whether or not one is justified in attempting to estimate the return of function in an extremity as a whole. To record an analysis of such a series from the standpoint of function in each individual muscle of the body, however, would require volumes of space, and the fundamental facts would be lost in a maze of figures. Therefore, an attempt has been made to estimate the residual function in an involved extremity and to compare this with the original involvement. For the original involvement only two listings have been used: (1) those extremities showing complete paralysis, including those in which no muscle is rated better than poor, and (2) those showing partial paralysis as evidenced by spotty changes or generalized weakness. For the estimated residual function in those extremities five classifications have been used:

1. Zero. Completely flail extremity or one with a few muscles showing no more than a trace in power.

2. Poor. Slight return, but with muscles rated no better than poor and consequently of little or no functional value.

3. Fair. Fair return in most muscles and perhaps good in a few, but with insufficient return in the more important muscles to permit a brace-free extremity. Such an extremity, even though a brace is required, is rendered fairly satisfactory, because the muscles are of considerable functional value.

4. Good. A satisfactory brace-free extremity. This means at least good return in the major muscles, but with some residual involvement. Extremities with good muscles about the hip and knee, but with residual involvement of muscles about the foot, are listed in this group.

5. Normal. Those extremities with no demonstrable residual involvement.

The same criteria have been used in estimating the return of power in the muscles of the upper extremity, except for the necessity of using apparatus. Upper extremities are frequently seen with the deltoid paralyzed, while the remainder of the extremity shows little or no involvement. Such extremities have been classified as good. It is obvious that such a classification is based on a rough estimate of the residual involvement. It is justified, however, since the amount of function which an extremity shows determines the value of the therapy used.

For a comparative study, all cases in this series have been grouped according to the type of treatment used. Table I shows seventeen cases (thirty extremities) which were treated by short periods of complete immobilization with no form of physiotherapy. This period of immobilization lasted from one to four months. The extremity was then protected by a brace and the individual was allowed up.

Table II shows six cases (ten extremities) treated by short periods of complete fixation for from one to three months and followed by physiotherapy for from three to six months. Protection of the extremity during the period of physiotherapy was maintained by plaster splints or specially prepared braces to prevent active use. Physiotherapy consisted of limited active and passive motion either in the pool, or on a table, in which case each treatment was preceded by baking and massage of the involved extremity. These treatments averaged about twenty minutes daily for five days each week.

TABLE I

Summary of Thirty Extremities Treated by Short Periods of Immobilization of One to Four Months without Physiotherapy *

Involved Part and Degree of Original Involvement	No.	Final Rating				
		Zero	Poor	Fair	Good	Normal
Arms						
Complete paralysis .						
Partial paralysis	6				3	3
Legs						
Complete paralysis . .	15	4	5	3	2	1
Partial paralysis	9			1	8	
Total extremities	30	4	5	4	13	4

* Of three patients with paralysis of the abdominal muscles, two had a final rating of poor and one, fair.

TABLE II

Summary of Ten Extremities Treated by Short Periods of Immobilization of One to Three Months in Solid Plaster Followed by Physiotherapy for Three to Six Months *

Involved Part and Degree of Original Involvement	No.	Final Rating				
		Zero	Poor	Fair	Good	Normal
Arms						
Complete paralysis						
Partial paralysis	1			1		
Legs						
Complete paralysis	4			3	1	
Partial paralysis	5			1	4	
Total extremities	10			5	5	

* Of two patients with paralysis of the abdominal muscles, one had a final rating of poor, and one of good.

Table III shows the results obtained in thirty-eight cases (seventy-five extremities) treated by prolonged immobilization for from four to eighteen months with no physiotherapy. For the most part this immobilization consisted of absolute fixation in solid plaster, and the remainder of the period in bivalved plasters or plaster splints.

Table IV shows an analysis of twenty-two cases (sixty-two extremities) treated by prolonged plaster immobilization followed, after three to twelve months, by continued immobilization and accompanying physiotherapy. Fixation of some form with no free active use of the extremity was maintained in all cases for periods of from eight to twenty-four months.

TABLE III

Summary of Seventy-Five Extremities Treated with Prolonged Plaster Immobilization of Four to Eighteen Months without Physiotherapy *

Involved Part and Degree of Original Involvement	No.	Final Rating				
		Zero	Poor	Fair	Good	Normal
Arms						
Complete paralysis	8		1	4	3	
Partial paralysis	7			1	4	2
Legs						
Complete paralysis	49	23	11	13	2	
Partial paralysis	11		1	5	5	
Total extremities	75	23	13	23	14	2

* Of the eleven patients with paralysis of abdominal muscles, two had a final rating of zero; six, poor; and three, fair.

TABLE IV

SUMMARY OF SIXTY-TWO EXTREMITIES TREATED WITH PROLONGED PLASTER IMMOBILIZATION OF THREE TO TWELVE MONTHS AND LONGER, FOLLOWED BY PHYSIOTHERAPY FOR EIGHT TO TWENTY-FOUR MONTHS *

Involved Part and Degree of Original Involvement	No.	Final Rating				
		Zero	Poor	Fair	Good	Normal
Arms						
Complete paralysis	14		1	7	6	
Partial paralysis	9				4	5
Legs						
Complete paralysis	28	13	6	8	1	
Partial paralysis	11			1	6	4
Total extremities	62	13	7	16	17	9

* Of the fourteen patients with paralysis of the abdominal muscles, one had a final rating of zero; six, poor; three, fair; two, good; and two, normal.

There are fourteen cases (nineteen extremities) listed in Table V in which delayed plaster immobilization was carried out over periods of from six to eighteen months in an attempt to improve function in extremities which were extensively involved. These patients were not seen by the authors in the beginning, and were not referred to this Hospital until several months after the onset of the paralysis. Immobilization was carried out by means of solid plaster with no physiotherapy. There might also be included in this group eighteen lower extremities and five upper extremities, already included in one of the first four tables, which

TABLE V

SUMMARY OF NINETEEN EXTREMITIES WITH DELAYED PLASTER IMMOBILIZATION OF SIX TO EIGHTEEN MONTHS IN AN ATTEMPT TO IMPROVE POWER (AFTER FOURTEEN MONTHS AND LONGER) *

Involved Part and Degree of Original Involvement	No.	Final Rating				
		Zero	Poor	Fair	Good	Normal
Arms						
Complete paralysis	1		1			
Partial paralysis	1					1
Legs						
Complete paralysis	13	6	6	1		
Partial paralysis	4			1	3	
Total extremities	19	6	7	2	3	1

* Of the three patients with paralysis of the abdominal muscles, one had a final rating of zero, and two, poor.

were later given additional complete plaster fixation of from six to twelve months because of extensive residual involvement. Not one in this latter group showed any improvement in muscle power as a result of the immobilization.

During this same four-year period, there was an additional series of sixty-three cases (129 extremities) shown in Table VI, which received no treatment whatever. These were patients who for the most part lived in inaccessible communities, and who usually were without the immediate services of an orthopaedic surgeon or physiotherapist. These patients were kept in bed only during the acute illness, and most of them were made to attempt to walk as soon as they could venture out of bed. In many instances, the parents felt that the paralysis would progress unless the child was forced to use the involved extremities and exercise them as much as possible. These patients were seen in the Clinic from six weeks to twelve months after the acute illness, and at the time either showed so much recovery that treatment in an attempt to improve the muscle power was not justified, or showed so extensive residual paralysis several months after the onset that treatment was thought to be a futile gesture. Since these patients did not have accurate muscle charts made early in the process, it may be argued that considering them in this discussion is not justified. The parents, however, were questioned as to whether the involved extremity in each instance showed complete or partial paralysis. This was determined by whether or not the patient lost all ability to move the extremity in question. If the extremity could not be actively moved, it was felt safe to assume that there was extensive involvement and to classify it as completely paralyzed. When some ability to move the extremity remained, the involvement was listed as partial paralysis.

The recovery of the involved abdominal muscles has not been con-

TABLE VI

SUMMARY OF 129 EXTREMITIES IN WHICH NO TREATMENT WAS USED *

Involved Part and Degree of Original Involvement	No.	Final Rating				
		Zero	Poor	Fair	Good	Normal
Arms						
Complete paralysis	28	2	2	4	9	11
Partial paralysis	12				8	4
Legs						
Complete paralysis	58	9	6	6	30	7
Partial paralysis	31		1	5	22	3
Total extremities	129	11	9	15	69	25

* Of the eight patients with paralysis of the abdominal muscles, one had a final rating of zero; two, poor; three, fair; one, good; and one, normal.

TABLE VII

RESULTS IN EXTREMITIES FOR EACH GROUP REGARDLESS OF DEGREE OF ORIGINAL INVOLVEMENT

Group and Treatment	Total No.	Zero		Poor		Fair		Good		Normal	
		No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Group I. . . . . Immobilization 1 to 4 months No physiotherapy	30	4	13	5	17	4	13	13	44	4	13
Group II. . . . . Immobilization 1 to 3 months Physiotherapy 3 to 6 months	10	0	0	0	0	5	50	5	50	0	0
Group III. . . . . Immobilization 4 to 18 months No physiotherapy	75	23	30	13	17	23	31	14	19	2	3
Group IV. . . . . Immobilization 3 to 12 months Physiotherapy 8 to 24 months	62	13	21	7	11	16	26	17	27	9	15
Group V. . . . . Delayed plaster immobilization 6 to 18 months	19	6	31	7	37	2	11	3	16	1	5
Group VI. . . . . No treatment	129	11	9	9	7	15	12	69	53	25	19
Totals.	325	57	18	41	12	65	20	121	37	41	12

sidered in the above discussion. Those with definite involvement have been mentioned as footnotes to the accompanying tables, with the reeovery shown in eaeh instanee. Treatment for these has eonsisted in an attempt to maintain relaxation in the abdominal wall at all times by keeping the patient on a flexed Bradford frame, or elevating the chest, shoulders, head, and neek on pillows. When a position of 10 degrees to 15 degrees or more of flexion is maintained for several months, many patients will develop flat ehests and round shoulders. Sueh treatment, therefore, must be carried out within reason. Any patient who showed any indieation of abdominal involvement was fitted with a Hoke type of eorset before being allowed to sit up. In spite of this preeaution, a definite scoliosis has already developed in twenty-one of these patients, or in about 13 per cent. of the total series. In two eases with distinct uni-

TABLE VIII

RESULTS FOR GROUPS COMBINED ACCORDING TO DEGREE OF ORIGINAL INVOLVEMENT

Degree of Original Involvement	Total No.	Zero		Poor		Fair		Good		Normal	
		No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Extremities with initial complete paralysis..	218	57	26	39	18	49	22	54	25	19	9
Extremities with initial partial paralysis.	107	0	0	2	2	16	15	67	63	22	20
Totals...........	325	57	18	41	12	65	20	121	37	41	12

lateral involvement, fascial transplants to the abdominal wall have been used in an attempt to splint the weak side and prevent further increase in the deformity, but insufficient time has elapsed to make any statement in regard to the result.

DISCUSSION

By a study of the tables, it can be readily seen that no particular form of therapy produced results which were outstanding. In fact, the highest percentage of satisfactory brace-free extremities occurred in that group of patients who received no treatment during the early stages, and who began to walk without support as soon as they could get out of bed.

The degree of initial paralysis was of far greater value in determining the degree of residual involvement than was the type of treatment used. Classifying all groups together, there were 218 extremities showing complete paralysis at the onset, and 107 extremities showing only partial paralysis. Final rating in each of these is shown in Table VIII.

Since early muscle charts were not obtained in the group that received no treatment, some may object to our assumption that some of these showed complete paralysis in the beginning. Let us assume then that none of these patients showed complete paralysis in the beginning, and classify all sixty-three patients (129 extremities) as having had original partial paralysis. Table IX shows that even then the results in this group compare very favorably with the combination of extremities from all other groups which showed only partial involvement in the beginning, and even the strongest objector will have to grant us the right to classify as complete paralysis those extremities which still remain flail or are now rated no better than poor. This change in the table will leave the group receiving no therapy with more brace-free extremities today—63 per cent. good and 23 per cent. normal—than the extremities showing only partial initial involvement in the combined therapeutic groups.

It seems safe to assume, therefore, that in the final analysis, the

TABLE IX

COMPARISON OF RESULTS BETWEEN ENTIRE GROUP THAT RECEIVED NO TREATMENT AND THE EXTREMITIES OF ALL OTHER GROUPS THAT SHOWED ONLY PARTIAL PARALYSIS AT ONSET

Group and Treatment	Total No.	Zero		Poor		Fair		Good		Normal	
		No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Group VI No treatment......	129	11	9	9	7	15	12	69	53	25	19
Combined extremities with original partial paralysis in all groups receiving therapy....	64	0	0	1	2	11	17	37	58	15	23
Totals..............	193	11	6	10	5	26	13	106	55	40	21

results in anterior poliomyelitis can be more adequately explained on the basis of the underlying pathological process than on the form of the early treatment which is used. Initial paralysis in many instances is on the basis of a block in the pyramidal tracts from localized oedema or hemorrhage without actual destruction of the ganglion cells. Such a paralysis is temporary in character; and muscle function returns with relief of pressure from the anterior horn cells with the subsidence of the oedema. Instances of only partial paralysis of an extremity in the beginning can easily be explained on this basis, and could account for their higher percentage of satisfactory results. Those extremities showing satisfactory functional return, in spite of apparent initial complete paralysis, can also be explained on this basis. If, instead of this temporary pressure paralysis, however, the anterior horn cells are actually destroyed, the muscles supplied by those nerve cells will remain completely paralyzed regardless of the type of treatment. In those cases with complete paralysis at the onset in one or more extremities, one can imagine a more destructive underlying pathological process. This actual destruction of nerve cells, rather than a temporary pressure block of the pyramidal pathway, probably accounts for the lower percentage of satisfactory returns in such cases.

The authors do not wish to imply from this that all orthopaedic measures should be discarded in the treatment of the acute stages of this disease. Careful immobilization should be used for three reasons: (1) for the comfort of the patient during the acute stage, (2) to prevent the early development of deformities in an extremity as the result of muscle imbalance, and (3) to prevent a stretch paralysis in a partially paralyzed muscle. That this can and does occur at times is evidenced by the fact that after the correction of deformities, return of power is occasionally noted in muscles which have been stretched over a long period. To be perfectly honest, it must be admitted that otherwise treatment has little

or no effect on the course of the disease. The type of treatment used in the authors' experience is of minor importance in restoring power to the paralyzed muscles, but may be used so long as that plan is carried out within reason and is not actually harmful to the involved muscles.

The continuation of physiotherapy over a period of years has often been used in the hope of obtaining some evidence of recovery in involved muscles. For patients who can afford such care and who do not have to consider the great economic side of this problem, such a plan may be ideal. Recovery in paralyzed or partially paralyzed muscles is not of as great importance in these patients, however, as their psychological well-being. If an extremity shows power enough to be rendered brace-free and functionally satisfactory by stabilizing operations and muscle transplants with a loss of time of only three to four months, it is not justifiable to substitute prolonged physiotherapy over a period of years in an attempt to accomplish a result which would functionally be no better. For the vast majority of patients who are compelled to consider the economic aspect of this question, this would seem to be a more sensible solution to their problem. In those patients with essentially flail extremities, it is not justifiable to prolong active physiotherapy in order to obtain an increase in power of involved muscles of as much as 10 to 15 per cent. After reasonable time has elapsed, it is better to permit this patient to be up with a brace and to utilize this time in adapting himself to the use of the brace and in learning some trade whereby he can carry on an independent existence throughout his life.

This question of how long treatment and immobilization should be continued before full active use of the extremity and weight-bearing are permitted, is extremely difficult to answer.

In the lower extremity, if there is residual involvement only about the foot with the rest of the extremity good or normal, the authors feel that this foot can be adequately protected in a brace and the child can as a rule be permitted up safely after three to four months. If no further recovery takes place in the foot, a satisfactory brace-free extremity can still be obtained by stabilization of the foot and muscle transplants, necessitating a minimum loss of time to the patient. If the entire extremity is involved, and is showing no evidence of improvement in power, as is frequently the case when the extremity is completely flail, weight-bearing is allowed with a brace after six months. While such may occasionally occur, the authors have seen no completely paralyzed extremity or muscle, which had been under adequate care and which remained flail six months after the onset of the paralysis, show a return of power sufficient to be of functional value, regardless of the form of treatment. If the muscles can be rated as high as fair and are still improving in power, immobilization should be continued until recovery is at a stationary point. The authors have set no exact time limit on this, but Bennett and Lenhard state that in their series all recovery was complete by the end of eighteen months. The authors do not feel that prolonging immobilization and physiotherapy over a

period of years is in any way indicated. Cases are seen in which prolonged immobilization and prolonged physiotherapy will increase the power of an involved muscle as much as 10 per cent., or increase from a trace to a rating of poor, but such is of little benefit to the patient, and is of little or no functional value. Such an improvement on a muscle chart is often construed as tremendously important. Unless the amount of improvement is sufficient to render the muscles of value from a functional standpoint, prolonged periods of immobilization and physiotherapy are not justified.

In the upper extremity, the same general plan of treatment is followed. If there is evidence of improvement, immobilization and protection are continued, but if an involved muscle remains completely paralyzed for six months, in spite of adequate constant protection and care, as is often the case in the deltoid, there is no reason for prolonging the active treatment.

SUMMARY

The results in this series of 160 cases of recent anterior poliomyelitis extending over a four-year period seem to indicate that the type of early treatment has little or no effect on the course of the disease and alters little, if any, the degree of residual paralysis which is seen.

Clinical evidence shows that the amount of residual involvement is primarily dependent on the degree of initial paralysis and the amount of actual destruction which has taken place in the anterior horn cells. There is no way of accurately determining this during the acute illness, but it is at this time that the die for the final picture is cast, and orthopaedic measures probably alter little, if any, the course of the disease.

Immobilization and protection are indicated for three reasons: (1) the comfort of the patient during the acute stage, (2) the prevention of deformities, and (3) the prevention of stretch paralysis in the involved muscles.

Therefore, the early orthopaedic measures actually employed are of little importance in restoring power to the paralyzed muscles, but may be used so long as they are not actually harmful to the involved muscles.

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THE INTERMUSCULAR, LATERAL APPROACH FOR REMOVAL OF A CERVICAL RIB *

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Several years ago the author had occasion to operate on a rather large cervical rib. The rib produced a considerable bulge on the side of the neck, and was so readily palpable that it seemed subcutaneous. The best way to remove this rib appeared to be the most direct approach through an incision on the lateral aspect of the neck directly in front of the trapezius muscle, instead of through an anterior horizontal incision over the sternomastoid muscle, which is far removed from the lateral surface of the vertebra, and hence from the proximal extremity of the rib. The lateral approach was used and the removal of the rib was found to be very simple. The author believes that it is not adequately appreciated that the lateral mid-cervical approach permits an unusually easy access to a cervical rib through an avascular, intermuscular route. He has used this avenue several times and on each occasion has found it safe, adequate, and satisfactory.

ANATOMY

In studying a cross section of the neck (Fig. 1), it is found that the cervical spine divides the neck into an anterior, prevertebral compartment containing the larynx, trachea, oesophagus, large blood vessels, the cervical and brachial plexuses, and many muscles, and a posterior compartment containing chiefly muscles arising from, or attached to, the posterior part of the skull and the lateral and posterior cervical vertebral processes. These compartments are separated laterally by extensions of the deep cervical fascia, which attach to the transverse processes of the cervical vertebrae. Thus at the level of the seventh cervical vertebra a cervical rib has its origin between the muscle groups of the prevertebral and postvertebral compartments. Moreover, it may be noted that at this site (Fig. 2), there are no important vessels or nerves requiring special attention. The spinal accessory nerve enters the trapezius considerably above the level of the seventh cervical, and the transverse cervical artery is below it. One might perhaps cut a few fibers of the supraclavicular cutaneous branches of the cervical plexus, but this is not a serious sacrifice. This arrangement of the tissues permits intermuscular access to the transverse process of the seventh cervical vertebra, and hence to a cervical rib.

TECHNIQUE

An oblique incision of two and one-half inches, parallel to the creases of the neck, is made in the posterior triangle of the neck a little below the

* Read before the Orthopaedic Section of the New York Academy of Medicine, February 21, 1941.

level of the cricoid cartilage, with the middle of the incision opposite the seventh cervical vertebra (Fig. 3). The superficial fascia and platysma are cut, exposing the deep fascia, which is incised vertically and retracted, exposing the trapezius posteriorly. The trapezius and the deep fascia are retracted backward. The tissues seen in the wound are, from before backward, the upper trunk of the brachial plexus, the scalenus medius and posterior and the levator scapulae. By gently retracting the levator scapulae backward, and the scalenus posterior forward the base of the cervical rib is immediately encountered (Fig. 4). The scaleni (posterior and median) are then gently elevated, exposing the entire length of the cervical rib and, when present, the fascial or aponeurotic band extending downward and forward from its tip. By cutting the rib near its origin, it can be raised from its bed to its very tip; the restraining tissues, including the fascial band, can be severed, and the rib liberated, freeing the plexus of the pressure caused by the rib and its band. The rib and the fascial band can be removed without the hazard of in-

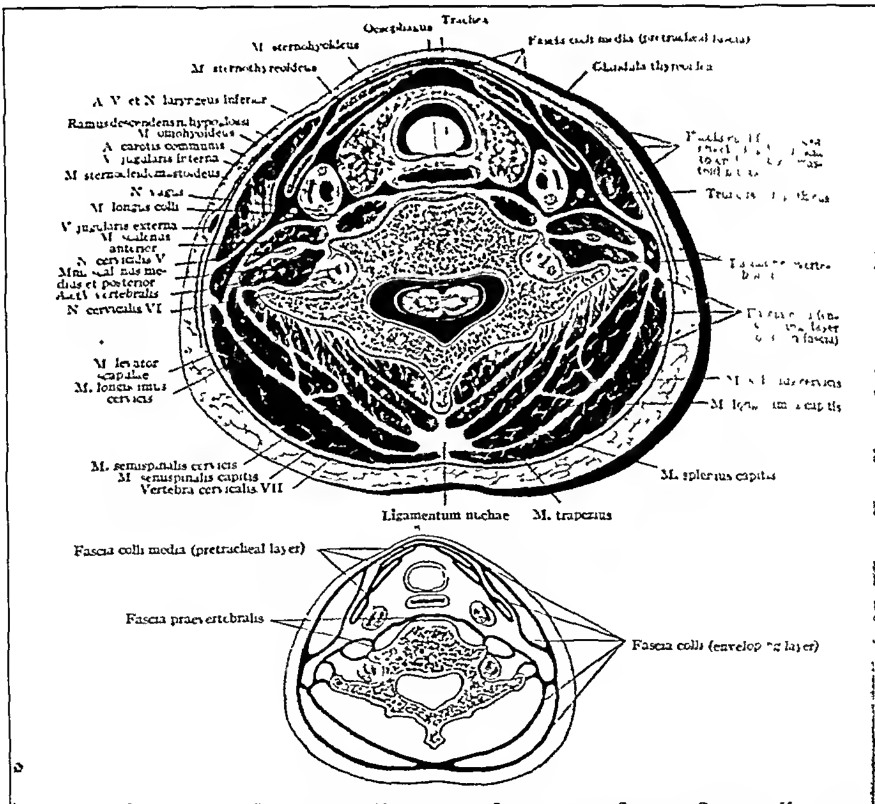

FIG. 280.—CROSS SECTION THROUGH THE NECK AT THE LEVEL OF THE SEVENTH CERVICAL VERTEBRA TO SHOW THE LAYERS OF DEEP CERVICAL FASCIA.
Inset delineates the fascial layers without reference to the structures they enclose.

FIG. 1

This section, from Callander's Surgical Anatomy, shows the intermuscular position of the transverse processes of the seventh cervical vertebra. (*Courtesy of W. B. Saunders Company.*[2])

jury to any vessels or nerves. In fact in this method of exposure the brachial plexus may not be seen, and need not be exposed. On the other hand, should it be desirable to inspect the scalenus anterior, it can readily be done by retracting the cut inner edge of the deep cervical fascia. When the rib is very large, bulging the scaleni forward, it may be advantageous to identify the interval between the posterior and median scaleni, retract them in opposite directions, and thus reach and expose the rib, perhaps more easily than in the plane between the scalenus posterior and the levator scapulae.

When a cervical rib causes symptoms, they are identical with those of the so-called scalenus anterior syndrome, and are due to a constriction of the space through which the brachial plexus and the subclavian artery pass from the neck into the axilla, with resultant abnormal pressure upon the plexus and the artery. The object of treatment is to relieve the pressure and irritation by enlarging the space for the plexus of nerves and the subclavian artery. This should be possible through either the removal of the anomalous rib, or division of the scalenus anterior muscle. There are cases, many of them, with classical symptoms, in which there is no cervical rib. In these instances the anterior approach, popularized by Adson and Coffey is preferable, because it affords a thorough exposure

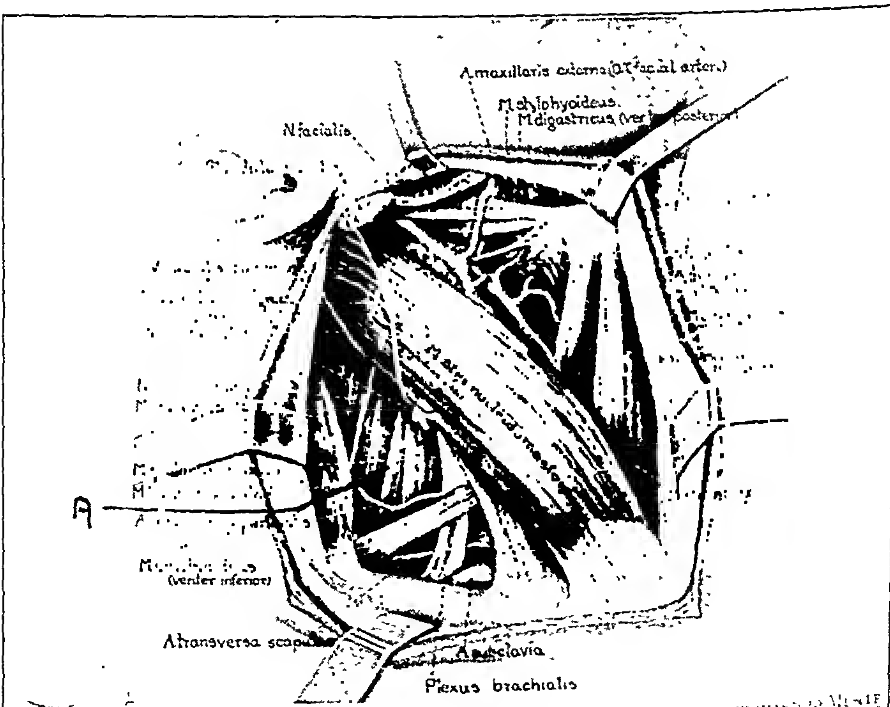

Fig. 340.—Structures of the Lateral Regions of the Neck with the Sternocleidomastoid Muscle in Situ.

Fig. 2

This photograph is also a copy of one in Callander's Surgical Anatomy. It shows that at the site of the transverse process of the seventh cervical vertebra, and hence the usual position of a cervical rib, there are no large or important vessels or nerves (*A*). (*Courtesy of W. B. Saunders Company.*[2])

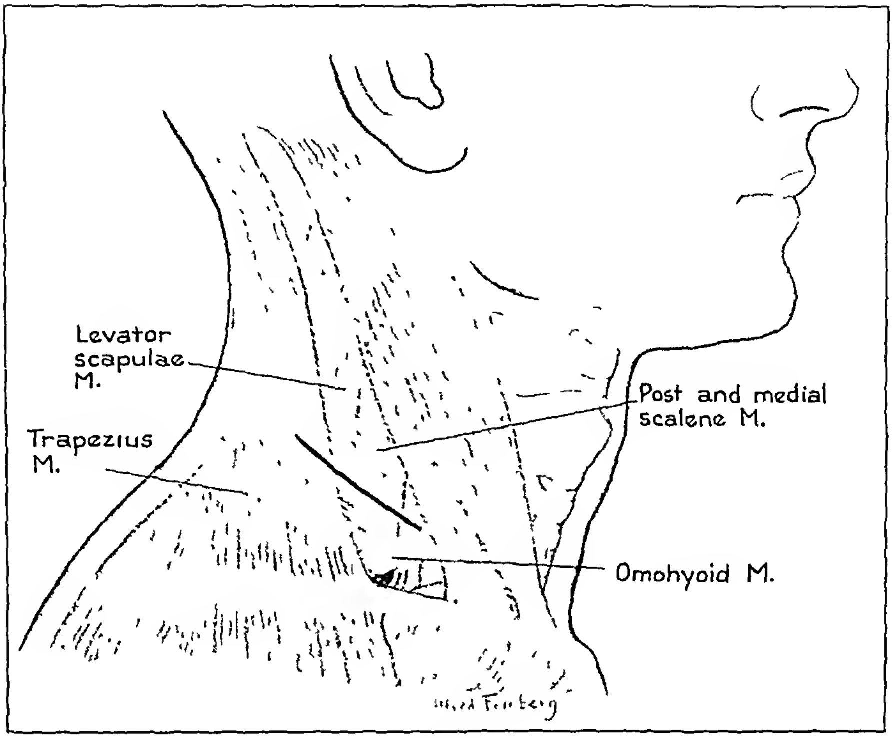

FIG. 3

The oblique dark line indicates the incisional approach for the removal of a cervical rib.

of the scalenus anterior, which is often the constricting agent and must be released. There are, however, cases like the first herein reported, in which the cervical rib was evidently responsible for the symptoms, or like the patient (Case 3) for whom transsection of the scalenus anterior two years before had not afforded relief, and who definitely required an exploration of the cervical rib. For these patients the lateral approach is indicated. Neither approach is entirely adequate for the thorough performance of a complete section of the scalenus anterior *and* removal of the cervical rib. Should both these structures require attention, one must employ a combination of the two exposures.

Adson objects to a lateral incision because the forward retraction of the posterior and median scaleni may irritate the brachial plexus. He states that paralysis has actually occurred from traction on the brachial plexus, but it would seem to the author that, by gently retracting the scaleni, only slight pressure would be applied to the nerves, and certainly far less than by attempting to remove the cervical rib through the interval between the upper and lower trunks of the brachial plexus as Adson advises. In the author's own experience, which admittedly thus far is too limited to be authoritative, the retraction of the scaleni has been possible by very gentle force, and has caused no nerve damage. Actually, in the lateral approach it is not necessary to expose

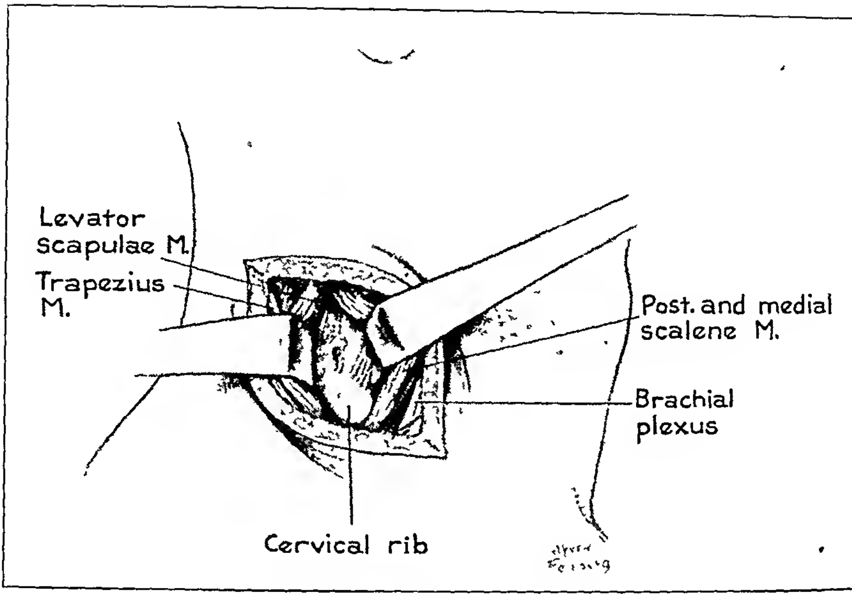

FIG. 4

In this drawing is outlined the intermuscular location of the cervical rib. The interval between the levator scapulae and the scalenus posterior must be identified. The levator is retracted backward and the scaleni forward, exposing the cervical rib in the interval between them.

any of the nerve trunks of the brachial plexus. And even if the upper cord or all of the cords of the plexus are exposed, they are seen so plainly that manipulation of them can be practically atraumatic. On the other hand, in the anterior approach for the removal of the rib one must expose not only the brachial plexus, but many other important structures, necessarily involving extensive handling or instrumentation of all of them.

CASE REPORTS

CASE 1. R. T., female, aged fifteen years, applied at the Clinic at the Hospital for Joint Diseases for treatment of a tumor on the right side of her neck. The examination revealed a mass, the size of a pigeon's egg, directly behind the clavicular portion of the sternomastoid muscle. The roentgenogram revealed bilateral cervical ribs arising from the seventh cervical vertebra. The rib on the right side was much larger than that on the left side, which accounted for the appearance of a tumor.

An operation was performed through an oblique four-inch incision on the lateral aspect of the neck. The cervical rib was exposed in the interval between the levator scapulae and the scalenus posterior. The cervical rib was found to articulate with the first true rib. The anterior extremity of the cervical rib was occupied by an osteochondroma. The cervical rib was osteotomized near its vertebral origin; was lifted up and freed from the adjacent tissues by dull dissection; and removed by disarticulating it from the first rib. Healing took place by primary union; there were no complications, and the patient was relieved of a conspicuous mass in the neck.

CASE 2. Mrs. L. G., forty-two years old, was referred to the author for persistent and increasing pain in the right arm, pain in the right side of the neck, and numbness of the small and ring fingers on the same side. The symptoms had appeared several months previously without any known cause. The examination revealed bilateral cervical ribs of approximately equal size. Up to this time she had not had any symptoms on the left side. She had had some conservative treatment before consult-

ing the author, who continued the conservative treatment for several weeks without any relief. She was, therefore, admitted to the Hospital for Joint Diseases for removal of the right cervical rib.

The operation was performed through a three-inch oblique incision over the lateral aspect of the right side of the neck at the level of the seventh cervical vertebra. The rib was easily exposed by the intermuscular route described in the consideration of the technique. The rib consisted of a large hornlike process from the tip of which extended a strong aponeurotic band, one-quarter inch wide, which extended downward and was attached to the first rib. When the band was cut, there was an immediate release of the first rib, and the whole shoulder seemed to drop down. The cervical rib was osteotomized at its base and readily removed. The pain in the neck and right arm persisted for several weeks, but ultimately was completely relieved, and the patient returned to her occupation, as a stenographer.

Case 3. Mrs. M. O., twenty-four years old, was referred for persistent severe pain in the right arm, which was relieved only when the patient remained in bed supporting her arm in a sling. She had had the symptoms for a number of years. Two years previously she had had an operation on the right side of her neck by an eminent surgeon who, in the absence of roentgenographic evidence of a cervical rib, diagnosed the condition as a scalenus anterior syndrome. At operation he found a greatly thickened and hypertrophied scalenus anterior which he sectioned. The symptoms, however. were not relieved. Consequently when the author saw this patient, he decided that the etiological basis for the continuation of the symptoms was an aponeurotic band, extending between the right transverse process of the seventh cervical vertebra and the right first rib, and causing pressure upon and irritation of the brachial plexus.

At operation the right transverse process of the seventh cervical rib was exposed in the manner already described. A small, narrow, but tight, fascial band extending from the transverse process down into the neck was found. The transverse process and the fascial band were easily removed. The brachial plexus was explored for possible adventitious bands pressing upon it, but none were found. The symptoms persisted for several weeks after the operation, but gradually faded out so that the patient was able to resume a normal, active life.

SUMMARY

The author does not intend to minimize the importance of the anterior approach when the essential element in the operation is the release of the scalenus anterior. It is, perhaps, needless to emphasize, that in undertaking the sectioning of the scalenus anterior, the surgeon must be continuously on his guard not to injure the many important structures lying underneath the sternomastoid muscle. Donald and Morton call attention to a patient operated upon through an anterior approach in whom the thoracic duct was lacerated. They quote Spurling and Bradford, who commented on the occurrence of temporary paralysis of the diaphragm following traction on the phrenic nerve which is in intimate relation with the scalenus anterior. In the lateral approach no such important structures are encountered. The author is not here entering a plea for the exclusive use of the lateral approach in cases with symptoms of the scalenus anterior syndrome, but wishes only to direct attention to the fact that, when it is primarily desired to remove a cervical rib or the band of connective tissue extending downward from it, the lateral approach offers a simple and safe method for its performance, and has the following distinct advantages:

1. Accessibility to the rib in the intermuscular region between the levator scapulae posteriorly and the scaleni anteriorly.

2. The entire rib can be removed by freeing its proximal extremity and elevating it from behind forward from the adjacent muscles.

3. The aponeurotic or fascial band extending downward from the tip of the rib, which itself often causes pressure on the brachial plexus and subclavian artery, can be severed, and its pressure effect removed.

4. The approach is avascular, since no important vessels are encountered.

5. There is little danger of damaging the brachial plexus and subclavian vessels because they are protected by retraction of the scaleni.

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GRADATION OF EWING'S TUMOR (ENDOTHELIAL MYELOMA) *

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The available literature contains no record of an attempt to grade Ewing's tumor, so a serious study has been made of thirty patients, particularly with reference to microscopic findings of the tumors, in an effort to find reliable data which would aid in grading the malignancy of this entity. These thirty patients were selected from a total of forty-two with similar tumors; the others were rejected because of insufficient data for the present purposes. This must be regarded purely as a preliminary investigation. Obviously, moreover, a study of this kind, regardless of how painstaking, is fraught with many pitfalls and personal-equation errors.

HISTORY OF GRADING MALIGNANCIES

To Broders [2] must be given the credit for introducing and popularizing the method of grading malignant neoplasms. In 1920, he published an analysis of 537 cases of carcinoma graded by the figures 1, 2, 3, and 4 to indicate the degree of malignancy, from the lowest to the highest. Among other things, he based the degree of malignancy upon the proportion of differentiated and undifferentiated tumor tissue, the number of cells with large nucleoli (so-called "one-eyed" cells), and mitoses. The Broders system of grading carcinoma is now generally accepted as being of definite prognostic value.

The grading of sarcoma has been attempted only within the past few years. Meyerding, Broders, and Hargrave [3,15] have published two papers dealing with the grading of soft-tissue sarcoma. They have divided these tumors into the following three types: (1) fibrous, (2) fibrocellular, and (3) cellular. This division was predicated upon the histopathology,—that is, (1) the extent of fibrogenesis, (2) the relative proportion of fibers and cells, and (3) the amount of differentiation of the cells.

ORIGIN OF EWING'S TUMOR

That endothelium is derived from the mesoderm [1] no one will question, though embryologists and histo-anatomists are undecided as to the composition of the mesoderm. Opinion is divided as to whether it is composed of a part of the ectoderm, or entoderm, or of both. The majority of observers favor the latter theory. If this be true, there is little wonder that the occasional Ewing's tumor, which portrays organoid or histoid qualities,

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may confuse even the most experienced observer as to whether it is atypical carcinoma or atypical sarcoma. Zeit, from a study of the morphological and histogenic characteristics of endothelial tumors, concluded that the cells were of a type intermediate between epithelial and connective-tissue cells.

The exact origin of Ewing's sarcoma, therefore, is still unsettled; what is known regarding its histogenesis is based on conjecture. In a previous article [11], one of the authors called attention to the different opinions which have been proposed by Melnick, Oberling, Connor, Ewing, Geschickter and Copeland, Kolodny, Colville and Willis, and Hirsch and Ryerson. The authors regard the tumor as of subperiosteal or intracortical perivascular endothelial origin, even though postmortem findings in one of their patients [5] revealed the left suprarenal gland involved by the tumor. They believe the tumor in the suprarenal gland was not a primary growth, unless this neoplasm is characterized by multiple primary origins. Further discussion of this topic is not apropos to the title of this paper.

The present study has been approached from a broad point of view, in an attempt to correlate the clinical findings, both subjective and objective, the roentgenographic evidence, and the therapeutic results with detailed microscopic data.

CLINICAL FINDINGS

Pain was the most constant single clinical finding in the thirty patients. Almost every one suffered at one time or another with pain of a boring or throbbing character, which was usually worse at night. All reported freedom from pain at intervals. As to the presence of fever and leukocytosis, which are believed to be commonly associated with Ewing's tumor at some time during its course, the records were not sufficiently complete for statistical purposes. The palpation of a tumor was not always possible because of overlying soft-tissue structures, or because of its location in an inaccessible region. Locally, the condition of the skin, circulation, and temperature were of little diagnostic value.

Of the series of thirty patients, nineteen gave a history of symptoms for a period of one year or less prior to admission. Only two of these are alive: one (Case 1) reported symptoms of twelve months' duration, and the other (Case 6) gave a history of symptoms of four months' duration. The latter had three biopsies and was given roentgen therapy and Coley's toxin, but did not have an amputation. Of those with symptoms from two to four years before admission (ten patients), two are living (Cases 26 and 28). One patient was excluded because no definite record of the duration of his symptoms was available (Case 18).

The average "tumor life" of the seventeen patients with symptoms of one year or less on admission was one year and five months, while for the eight patients with symptoms of more than one year's duration, the average tumor life was five years and seven months. What significance,

if any, may be placed in the fact that those with symptoms of two years or more before admission lived an average of four times as long as the group with symptoms of one year or less, we are not prepared to state definitely. Rather than attribute any significance to the longer duration of symptoms as having, of itself, anything to do with the longer average tumor life, we would prefer to call attention to the possibility that the higher average mitotic-figure count—7.2 in the first group, with a short history, as compared to a count of 6.3 in the second group, with a longer history—is the important factor in the resultant disproportion of length of tumor life of the two groups of approximately four to one. There were eight, or 42 per cent., of nineteen patients in the group with the shorter preadmission clinical course, with nine or more mitotic figures, against two, or 20 per cent., of ten patients in the group with a longer preadmission course. The duration of symptoms and mitotic-figure count may be interrelated and even interdependent; a long tumor history may be associated with diminished cellular activity.

SITE OF PRIMARY TUMOR

In two (Cases 1 and 6) of the four living patients, the primary tumor was in the tibia, while in the other two, the tumors were in the femur and ulna respectively (Cases 26 and 28). The average tumor life of the nine patients with the primary tumor either in the pelvic bones, ribs, or vertebrae was two years and one month whereas the tumor life of those with a lesion of the extremities (fifteen patients) was three years and four months. Thus, as a rule, those patients with a lesion in the torso lived a much shorter time than those with a tumor in the extremities. Whether the anatomical site or the type of treatment each group received, or both, was responsible for this disproportion in the length of tumor life cannot be definitely stated. The tumors of the torso had an average mitotic-figure count of seven and four-tenths as compared to an average count of six and four-tenths in those of the extremities.

ROENTGENOGRAPHIC FINDINGS

Condensation, as revealed by roentgenograms, is the earliest bone manifestation of Ewing's tumor, being especially apparent in young patients. In a previous publication, one of the authors [4] called attention to three stages of osseous change presented by the tumor in the roentgenograms, as follows: "(1) condensation of the shaft of the bone without reaction of the periosteum . . .*; (2) the typical invasion with expansion, striation, and destruction of the cortex, and reactive bone production of the periosteum in layers (onion peel) . . . ; (3) disintegration of the periosteal layers and shaft with extension of the tumor to surrounding parts. The remains of the periosteum are apparent by marked lipping near the junction of the normal shaft and the tumor". It occurred to the authors,

* This stage, unfortunately, is observed rarely as most cases are not seen at so early a period . . .

therefore, to compare roentgenograms of patients seen early with those of patients seen after real bone destruction had taken place, to determine whether these observations would reflect in any way the degree of malignancy. Six patients, five of whom are dead, were first seen during the stage of condensation only of the bone, and twenty-three, twenty-one of whom are dead, were observed after bone destruction had taken place. The average duration of symptoms before admission in the five of the former group was ten months, as compared to a life of eleven months after admission and the institution of radical treatment. In the group of twenty-one patients, the average duration of symptoms before admission was one year and four months, as compared to an average life of one year and seven months after admission. The tumor-life average in the first group was one year and nine months, whereas in the second group it was two years and eleven months. The average mitotic-figure count was eight and two-tenths in the first group, as compared to seven in the second group. This is believed to be of prognostic significance.

The above observation seems to contradict previous teachings insofar as it relates to Ewing's tumor,—that is, that the sooner a diagnosis is made and radical treatment applied, the better will be the prognosis. According to the authors' observations, therefore, if a patient is seen with the earliest roentgenographic osseous reaction to the tumor—namely, condensation—a more guarded prognosis should be made than if he is seen later, after bone destruction has taken place. This would seem to lend support to recent deductions made by Ferguson from a study of 400 cases of osteogenic sarcoma gathered from the Registry of Bone Sarcoma of the American College of Surgeons, to the effect that if a patient is seen in the early course of the disease (first six months) and treated conservatively (with roentgenotherapy, for example), a better prognosis may be given than if radical treatment, such as amputation, has been instituted. Ferguson concluded that the factor of time influences the prognosis. It is likely, however, that the real factor in this apparent paradox is the cellular activity as measured by the mitotic-figure count.

TREATMENT

The treatment of the authors' patients included amputation for fifteen patients, or 50 per cent.; resection for two patients, or 6.6 per cent. (Cases 13 and 16); roentgen therapy for twenty-six patients, or 86.7 per cent.; and Coley's toxin for eight patients, or 26.7 per cent. (Cases 6, 8, 10, 11, 13, 16, 21, and 28). The four (13.3 per cent.) living patients (Cases 1, 6, 26, and 28) were treated as follows: Case 1, A. L. M., amputation, alive fourteen years after onset of symptoms; Case 6, J. O. T., roentgenotherapy and Coley's toxin, alive ten years and nine months; Case 26, M. H., radium, roentgenotherapy, and amputation, alive five years and six months; and Case 28, B. C., roentgenotherapy and Coley's toxin, alive three years and six months. The authors wish to emphasize the fact that the tumors of all but one of the four living patients fell in the group with

Mitotic Cell Activity

That mitosis is an evidence of cellular growth activity is recognized by all pathologists. A given number of mitotic figures per microscopic high-power field will indicate, in a measure, at least, the relative degree of cell activity in a tumor. In addition, the sizes and forms of the mitotic figures is thought to express to some extent the malignant proclivities of a tumor. Atypical, bizarre-shaped mitotic figures were seen in practically all of the tumors. The series were studied with the foregoing ideas in mind, and the tumors were divided into three grades, according to the number of mitotic figures per high-power field. There were fourteen tumors in Grade 1, with from one to five mitotic figures; nine in Grade 2, with from six to ten figures; and seven in Grade 3, with from eleven to fifteen figures.

Of the thirty patients, four (Cases 1, 6, 26, and 28) are living, fourteen years, ten years and nine months, five years and six months, three years and six months, respectively. The other twenty-six patients died of metastases. The tumors of the first two and the fourth living patients were of Grade 1, while that of the third fell in Grade 2. The family physician * of the latter patient recently informed the authors that there was no evidence of recurrence of the tumor, five years and six months after the onset of symptoms.

The average length of tumor life of the patients with Grade 1 tumors was three years and nine months, excluding Case 18; the longest was eleven years (Case 8); and the shortest was eleven months (Case 3). Two patients (Cases 8 and 13) lived eleven years and five years and seven months, respectively. Excluding those living over five years (Cases 1, 6, 8, and 13), the average tumor life was two years; the longest three years and six months (Case 28), and the shortest eleven months (Case 3).

The eight patients with tumors in Grade 2 had an average tumor life of three years and nine months. The longest was nine years and six months (Case 11), and the shortest one year and five months (Case 12). If all the patients who lived over five years were excluded (Cases 11, 16, and 26), the average tumor life of the remaining six would be two years and five months; the longest, three years and eight months (Case 22), and the shortest, one year and five months (Case 12).

The average tumor life of the seven patients with tumors in Grade 3, having eleven or more mitotic figures per high-power field, was one year and six months; the longest was two years and ten months (Case 23), and the shortest was eight months (Case 27). All the patients with tumors in this grade are dead.

The difference of approximately two to one in the length of life from the onset to death between patients with Grade 1 tumors, exclusive of those who are living, and the patients with Grade 3 tumors is obvious, whereas, if the living patients are included in Group 1, the difference increases to approximately three to one. The difference in the length of

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life of the patients with Grades 1 and 2 tumors is less striking. This is explained by the fact that in four, or 44 per cent. (Cases 11, 12, 17, and 26) of the nine tumors in Grade 2, the mitotic-figure count was only six, which would place these four on the border line between the two groups. One of the four patients (Case 11) lived nine years six months after the onset of symptoms.

Although from this microscopic data one cannot state that a patient will live a certain period merely because of a mitotic-figure count of five or less, one can state that such a patient's life expectancy is two to one better than that of a patient with a mitotic-figure count above ten.

SUMMARY AND CONCLUSIONS

The grading of Ewing's tumor, as of carcinoma and sarcoma, is exceedingly difficult. A number of factors make this so, among them, and most conspicuous in this study, is the total lack of differentiation of the tumor cell. This being true, the prognosis should always be guarded.

In order to discover, if possible, some criteria for estimating the degree of malignancy of Ewing's tumor, we have made a study of thirty cases from the standpoint of clinical findings, roentgenograms, therapeutic results, and microscopic features. The nuclear chromatin content, and the cell activity as measured by the number of mitotic figures per high-power field, seem to be the most significant of our findings. A classification of the tumors according to their chromatin content indicates that those containing a large number of chromatin knots are probably more malignant than those containing a lesser number.

In studying the cellular activity, the tumors were divided into three grades, according to the number of mitotic figures in a high-power field, as follows: Grade 1, one to five figures; Grade 2, six to ten figures; and Grade 3, eleven to fifteen figures. It would appear that a patient with a tumor having five or less mitotic figures (Grade 1) has approximately a 23-per-cent. chance to survive ten years and a 31-per-cent. chance to live five years, whereas, if the mitotic-figure count is eleven or above (Grade 3), he will probably live little over one year. None of the patients with tumors in Grade 2 of this series lived ten years, and three, or 33 per cent., lived over five years, one of whom is alive five years and six months after the onset of symptoms.

The roentgenographic evidence presented by these thirty cases indicates that the early stage, characterized by bone condensation, goes hand in hand with increased cellular activity, whereas late bone changes are usually accompanied by diminished cellular activity.

This group of cases is obviously too small from which to draw any definite conclusions regarding the gradation of Ewing's tumor. The authors propose, however, to continue their studies and trust that others will carry out similar investigations. Studies of large numbers of cases might throw more light upon this subject and lead to the discovery of a method of establishing a more accurate prognosis.

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SCOLIOSIS COMPLICATED BY SPINAL-CORD INVOLVEMENT

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Scoliosis complicated by cord involvement is an unusual condition, as a review of the literature indicates. The seven cases to be presented in this clinical review were selected from a series of 2,000 cases of scoliosis of all types, excluding those of a traumatic or inflammatory nature directly or indirectly related to the spine. Mauclaire, in 1913, first described the clinical picture of cord involvement due to scoliosis. Ridlon in 1916, Steindler in 1929, and Viets and Clifford in 1932, also described this clinical entity.

There appears to be no consistency as to the age of the patient at the onset of the neurological manifestations. The youngest patient in this series was six years of age, and the oldest was twenty-one. The average age of incidence was fifteen years. Although it is not an exact rule, the usual time of occurrence of neurological signs is during adolescence and the period of rapid growth[1].

In this series of seven cases, three were associated with rachitic scoliosis, three with congenital scoliosis, and one of doubtful etiology was associated with neurofibromatosis (von Recklinghausen's disease). In no instance was cord involvement observed in the paralytic or habitual type of scoliosis.

In each instance the scoliosis was of a severe type, with the exception of one case which was considered moderate. This moderate case, however, was associated with a kyphosis. The paralytic signs developed regardless of the direction of the primary curve. It was observed, however, that all the primary curves involved the high thoracic or cervicothoracic area. Roentgenograms revealed that the primary curve was one with a sharp angulation. There were two right thoracic; one right thoracic, left lumbar; one left cervicothoracic, right thoracic; one left cervicothoracic, right lumbar; one right thoracolumbar; and one left thoracic, right lumbar.

The apex of the primary curve in three cases was found to be at the level of the seventh thoracic, in two at the tenth thoracic, and in two at the fourth thoracic vertebra. There appears to be a definite relation between the level of the apex and the rapidity of development of the neurological signs. The three patients with the apex of the curve at or above the level of the seventh thoracic vertebra showed rapid progress of the clinical signs (Cases 4, L. S.; 6, M. L.; and 7, C. N.).

The paralysis developed in spite of what seemed to be adequate

* Service of Arthur Steindler, M.D.

conservative support and treatment. The treatment of the scoliosis in the preparalytic state consisted of exercises, braces, corrective casts, and traction on the torso. One case of paralysis developed during the period while the patient was undergoing traction.

The paralysis progressed rapidly in three cases, slowly in three, and remained stationary in one case. The patients who had a rapid progression of clinical signs and symptoms were those previously mentioned as having high curves of a severe nature.

Six of the seven patients had both sensory and motor changes. The motor involvement was typical of an upper motor-neuron lesion with spasticity. One patient had only a sensory disturbance but had a laminectomy five months after the onset of the sensory signs.

In three patients the motor signs appeared first and the sensory disturbance followed; in four the sensory manifestations were noted before the motor signs.

Trophic changes appeared in only one patient, in the form of a trophic ulcer over the buttocks. Sympathetic involvement was recorded in only one case prior to operations, and this involvement was of the bladder. Of the seven patients, only two had symmetrical manifestations,—six were involved bilaterally, and one unilaterally.

No single series of cases or collective review seems large enough to establish any uniform method of treatment to fit every case of cord involvement due to scoliosis. It is impossible to state from roentgenographic examination whether or not there is a direct encroachment on the cord by the osseous portion of the spine. It is definitely known that the signs and symptoms will clear up under conservative treatment (Case 5, LaV. F.), but will shortly recur unless under strict observation with adequate immobilization.

Six of the patients in this series had an adequate trial of conservative treatment; the one with only sensory changes was laminectomized early. Only two patients showed improvement under traction,—in one the improvement was considerable. The improvement in both was temporary, however, and there was a return of the neurological manifestations.

Spinal fusion gives no assurance of arresting the progress of the symptoms and signs. One patient (Case 1, B. K.) had a fusion operation by the combined method of Steindler[5], and there was an increase in the neurological manifestations in spite of a solid bony fusion of adequate length. The neurological signs slowly progressed over a period of four years, at which time the patient reached the end of her growing period[6].

Once the condition has been observed and a complete or partial block is believed present, laminectomy seems to be the method of choice. The literature offers ten cases in which laminectomy was performed.

Five of the authors' patients were treated by laminectomy and four showed definite improvement,—the one (Case 3, S. R. S.) showing no improvement died three years postoperatively of pneumonia. An autopsy was not allowed. The results of the operative procedures are

taken up in detail in the case histories and neurological charts. The results of laminectomy were considered good when the patient showed a complete or nearly complete restoration of his motor status, and at least partial recovery of his sensory status. The only sequelae in the patients in whom the results were considered as good were a small patch of impairment of superficial sensation and a slight motor weakness of the lower extremities, noted after strenuous or prolonged exercise. The findings at the time of the laminectomy were torsion of the cord in four cases, and direct pressure on the cord in only one. The direct pressure was from a bone ledge and not from direct

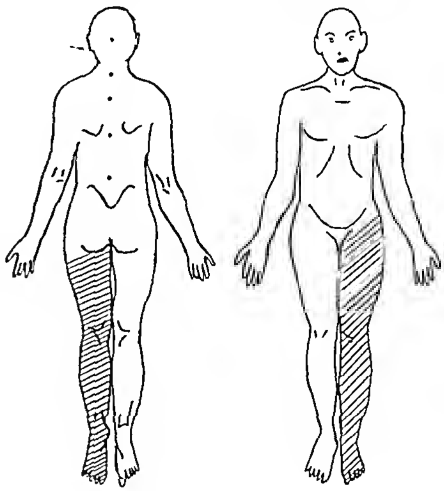

FIG. 1-A

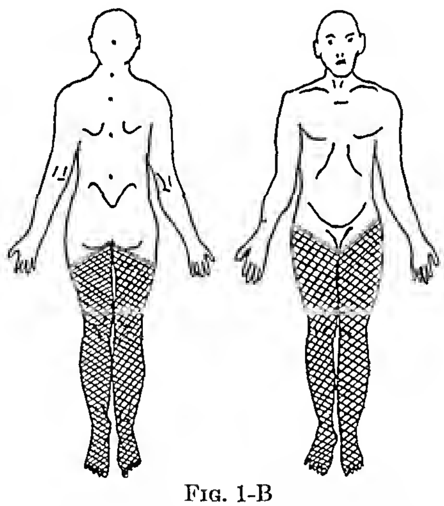

FIG. 1-B

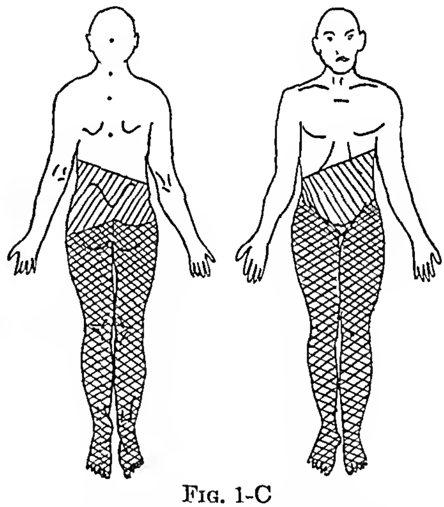

FIG. 1-C

Fig. 1-A: Case 1. B. K. (C-3656), October 29, 1929, aged six, was admitted with a moderately severe right thoracic, left lumbar curve, nineteen months before fusion. The motor signs had appeared prior to the sensory.

Hatching shows area of diminished sensation to pain, cotton, and temperature.

Gait: There was slight weakness and spasticity of the left leg.

Reflexes: Increase in knee jerk and Achilles tendon; no ankle clonus or Babinski.

Fig. 1-B: Case 1. B. K. (C-3656), January 17, 1933, twenty months after fusion.

Cross hatching shows sensation to pain, diminished; to cotton, 50 per cent.; to temperature, absent.

Gait: There was increased spasticity and generalized muscle weakness of both legs.

Reflexes: Bilateral knee jerk + + +; bilateral Achilles tendon + + +; bilateral ankle clonus.

Fig. 1-C: Case 1. B. K. (C-3656), May 1, 1935, four years after fusion.

Hatching shows area of diminished sensation to cotton; and cross hatching, area of anaesthesia.

Gait: There was spasticity and generalized muscle weakness of both legs. Patient wore short leg braces and used crutches.

Reflexes: Bilateral knee jerk + + + +; Achilles tendon + + + +; ankle clonus; Babinski.

compression by the vertebra. The dura was opened in all cases, and in four there was no evidence of a total block. In all patients on whom a laminectomy was performed, the possibility of cord tumor had been considered.

In two patients who had exploratory operations eighteen months and fourteen months following laminectomy, it was found that the defect was filled in with tough fibrous tissue. Intermingled in this tough fibrous tissue there were many bone spicules, but there was no actual bony closure of the laminal defect. The combination of fibrous tissue and islands of bone within this tissue made it necessary to use rongeurs in reopening the laminal space.

CASE REPORTS

CASE 1. B. K. (C-3656), aged six years, was admitted with a right thoracic, left lumbar curve which had been noticed eighteen months before admission. Although the history was not adequate, it was believed to be a congenital curve. For six months before entrance the curve had been increasing rapidly.

Physical examination revealed a moderately severe right thoracic, left lumbar scoliosis which was in the compensated position. There was a suggestion of weakness and spasticity of the left leg with an increase in the patellar and the Achilles tendon reflexes. Babinski and ankle clonus were absent. There were diminished sensations of the left lower extremity (Fig. 1-A).

The treatment was conservative and expectant over a period of one year. In spite of what seemed adequate support, an increase in the curvature was noticed, the spasticity

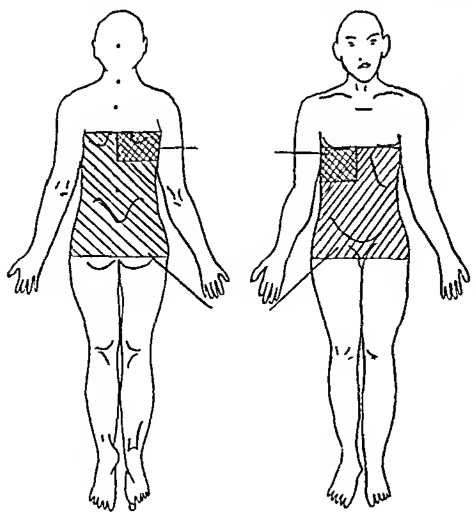

FIG. 2-A

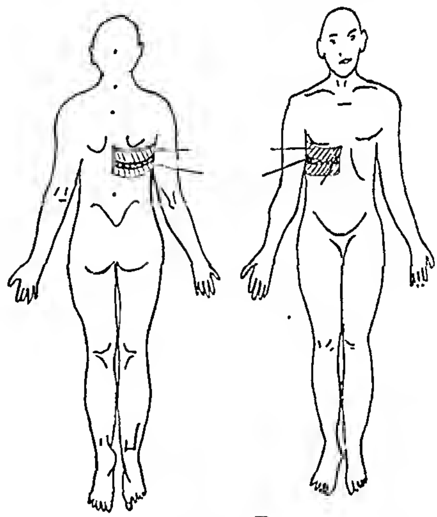

FIG. 2-B

Fig. 2-A: Case 2. H. C. (38/10918), May 16, 1936, aged fourteen, eighteen days before operation, had a moderately severe left thoracic scoliosis. The sensory signs had appeared prior to the motor signs.
Hatching shows area of diminished sensation; and cross hatching, loss of sensation.
Gait: There was spasticity in the left leg.
Reflexes: Knee jerk +++.
Spinal fluid: Pressure six millimeters of mercury; no rise on jugular pressure; globulin +++; lymphocytes eight per 100 cubic millimeters.

Fig. 2-B: Case 2. H. C. (38/10918), July 3, 1936, one month following operation.
Hatching shows area of diminished sensation; and cross hatching, loss of sensation.
Gait: Normal; no spasticity of the left leg.
Reflexes: Normal.

of the gait was pronounced, all reflexes of the lower extremities were exaggerated, a Babinski was present, and a sustained ankle clonus was present bilaterally.

An attempt was made to relieve the possible cord pressure by correction in a Risser jacket. Correction of the curve was satisfactory, but there was no improvement in the neurological signs. A fusion of the spine was done at this time, nineteen months after admission.

The fusion held well and there was no increase in the scoliosis. In spite of a successful fusion, the neurological signs increased (Figs. 1-B and 1-C).

CASE 2. H. C. (38/10918), aged fourteen years, was admitted May 16, 1936, with a moderately severe left thoracic scoliosis of two years' duration. The spine was extensible. On admission there was no evidence of neurological disturbances. The curvature was thought to be rachitic.

Conservative treatment was carried out until June 3, 1936, at which time the patient complained of a tingling sensation in the feet and a spastic gait of the left leg (Fig. 2-A). Laminectomy was performed on the thoracic spine from the first to the fifth thoracic vertebrae. The cord was found to be pulsating and no direct pressure could be found. There was, however, a distinct tension of the cord due to torsion. The postoperative course was uneventful.

One month after the operation there was a distinct improvement in the sensory findings; no pathological reflexes could be elicited; and the spasticity had disappeared (Fig. 2-B).

A spine fusion was performed on October 6, 1937. The soft tissues were stripped from the transverse process for a short distance laterally and the bone bed made at the junction of the transverse process with the lamina just distal to the superior articular

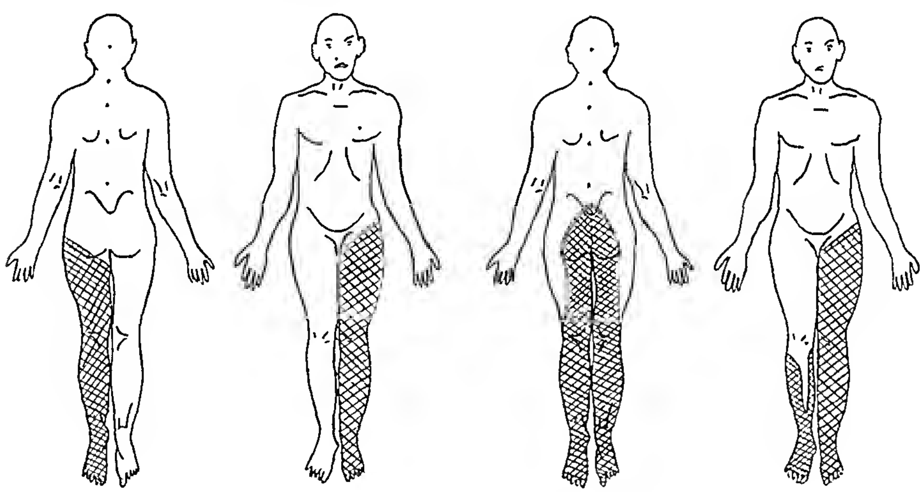

FIG. 3-A FIG. 3-B

Fig. 3-A: Case 3. S. R. S. (F-11), October 9, 1930, aged twenty-one, was admitted with the diagnosis of severe thoracolumbar kyphoscoliosis, twelve weeks before operation. Patient was unable to tell whether motor or sensory signs had appeared first. Bowel and bladder were normal.
Cross hatching shows area of anaesthesia.
Gait: There was spasticity of left leg.
Reflexes: All hyperactive; bilateral ankle clonus.

Fig. 3-B: Case 3. S. R. S. (F-11), November 30, 1932, twenty-two months after operation. There was bowel and bladder retention.
Cross hatching shows the area of anaesthesia.
Gait: There was spasticity of both legs.
Reflexes: Bilateral ankle clonus.
Patient was followed for three years, during which time there was no return of function. Patient died from pneumonia.

process. When sufficient bone bed had been developed, a tibial graft was laid on the bone bed throughout the entire region of the laminectomy on both sides of the spine. The result was good.

Case 3. S. R. S. (F-11), an achondroplastic dwarf, aged twenty-one years, was admitted October 9, 1930, with a severe lumbar kyphoscoliosis. Nine months before admission the patient had been unable to lift the left foot off the ground, and had noticed also a disturbance of sensation.

Physical examination showed a marked thoracolumbar kyphoscoliosis, and marked spasticity of the left leg with anaesthesia (Fig. 3-A). The reflexes were hyperactive and there was bilateral ankle clonus. Bowel and bladder control were normal.

Traction on a curved frame was carried out for twelve weeks with no improvement; so, on January 25, 1931, a laminectomy was performed including the ninth to the twelfth thoracic vertebrae. There was an absence of pulsation, but no direct pressure, and a torsion of the cord was found. Immediately after the operation there was bladder retention, loss of bowel control, and an increase in the area of anaesthesia (Fig. 3-B). On opening the incision, large blood clots were found and removed. Suprapubic drainage was necessary.

The patient died three years later of pneumonia without having had any return of function.

Case 4. L. S. (38/15458), aged sixteen years, was admitted May 27, 1936, with a diagnosis of a left thoracic scoliosis and von Recklinghausen's neurofibromatosis. The scoliosis had been recognized two and one-half years before admission, and had been increasing rapidly. On admission all reflexes of the lower extremities were exaggerated,

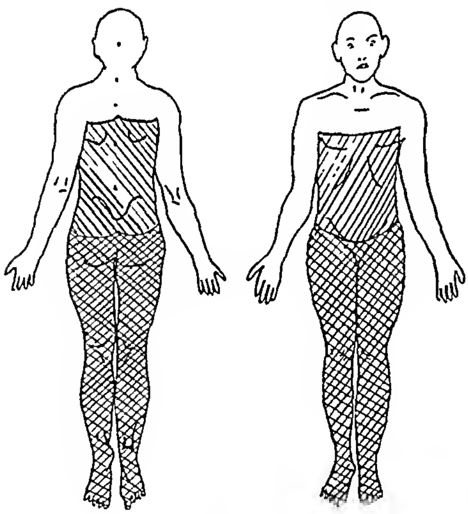

Fig. 4-A

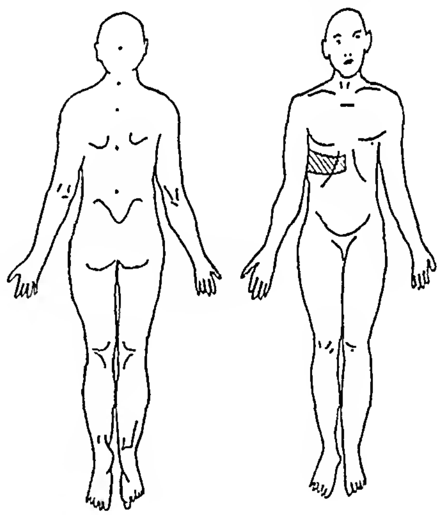

Fig. 4-B

Fig. 4-A: Case 4. L. S. (38/15458), aged sixteen, was admitted May 27, 1936, with a left thoracic scoliosis, von Recklinghausen's neurofibromatosis, and no sensory changes. The chart shows changes in sensation on June 16, 1936, five months before operation. The motor signs had appeared prior to the sensory.

Hatching shows area of diminished sensation; and cross hatching, area of anaesthesia.

Gait: There was progressive spasticity; generalized weakness of legs.

Reflexes: Exaggerated; Babinski; ankle clonus.

Spinal fluid: Sugar eighty-six milligrams per 100 cubic centimeters; protein 260 milligrams per 100 cubic centimeters; pressure eight millimeters of mercury; no increase on jugular pressure.

Fig. 4-B: Case 4. L. S. (38/15458), July 25, 1939, thirty-two months following operation. Patient wore back brace and had just started weight-bearing.

Hatching shows area of diminished sensation.

Gait: Power in the lower extremities was increasing.

a Babinski was present, and a sustained ankle clonus. There were no sensory disturbances on admission.

The patient was placed in traction and treated conservatively until June 16, 1936, when sensory changes were revealed as well as motor involvement (Fig. 4-A). Traction was continued until November 17, 1936, with no improvement in either the motor or sensory conditions.

On November 17, 1936, a laminectomy was performed from the seventh cervical to the sixth thoracic vertebrae. On exposure of the cord a definite kink was demonstrable at the level of the third and fourth thoracic vertebrae. There was pulsation of the cord, and no direct pressure was found.

Immediately after the operation there was an exaggeration of all symptoms and signs, with a loss of bowel and bladder control. Because of the persistent increase in neurological signs the wound was opened three days following the laminectomy and

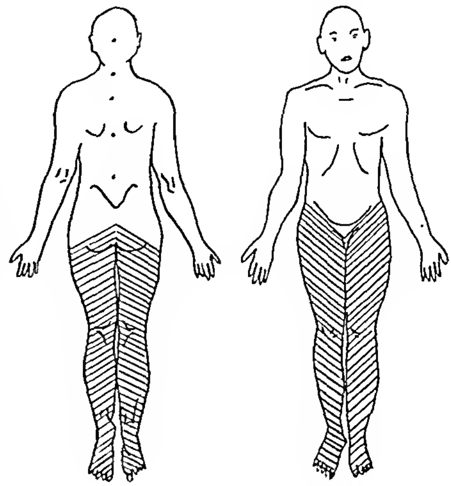

Fig. 5-A

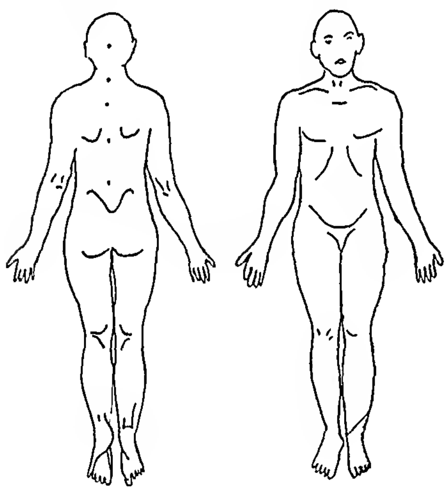

Fig. 5-B

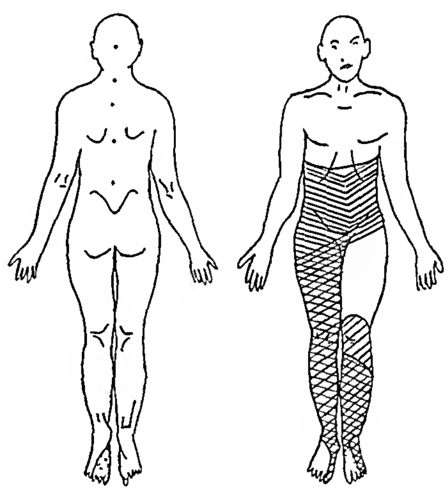

Fig. 5-C

Fig. 5-A: Case 5. LaV. F. (38/15079), February 15, 1938, aged thirty-three, twenty-six years after onset of scoliosis and six months following onset of the neurological signs, was admitted with a marked right thoracolumbar scoliosis with rotation.

Hatching shows sensation to pain, absent; to cotton, 75 per cent.; to temperature, normal.

Gait: Spastic; ataxic; general muscle weakness of legs; patient used crutches.

Reflexes: Knee jerk ++; Achilles tendon ++; ankle clonus; Babinski.

Fig. 5-B: Case 5. LaV. F. (38/15079), May 11, 1938, after three weeks of head and pelvic traction.

Stippling shows area of hyperaesthesia.

Reflexes: Same as on February 15, 1938.

Fig. 5-C: Case 5. LaV. F. (38/15079), November 13, 1939.

Hatching shows area of diminished sensation; cross hatching, area of anaesthesia; and stippling, area of hyperaesthesia.

Gait: Unable to walk.

Reflexes: Knee jerk ++++; Achilles tendon ++++; Babinski; ankle clonus; loss of position sense.

Spinal fluid: Rise on jugular pressure.

several large clots expressed. The operative site was drained with penrose tubing for twenty-four hours.

Examination on February 1, 1937, three months after operation, revealed a definite improvement in sensory and motor involvement. The bowel and bladder disturbances had cleared up. The sensory disturbance was the first to improve. Since February 1, 1937, the patient has made a slow but steady progress. There is still some weakness of the lower extremities, in greater part due to disuse; there is also a decrease in the spasticity, as well as less exaggeration of the reflexes (Fig. 4-B).

Case 5. LaV. F. (38/15079), aged ten years, was first seen March 27, 1915, at which time he had a marked right thoracolumbar scoliosis with rotation. The condition was partially corrected and a cast was applied with the patient on the Abbott frame. He wore a scoliosis brace until 1923. The patient was lost to the Clinic for five years and became considerably worse. In January 1928, he revealed hyperactive reflexes and a positive Babinski. Traction on a curved frame relieved his symptoms and he was allowed to be ambulatory in a brace. He was again lost to the Clinic until February 1938, at which time the scoliosis had increased and the neurological signs revealed cord involvement (Fig. 5-A). The patient was placed in traction and showed marked improvement (Fig. 5-B). He was then allowed to return home on condition that traction be maintained. The traction was not carried out and he again became progressively worse, until walking became an impossibility (Fig. 5-C). Laminectomy was not performed because of his poor physical condition. The spine is still uncompensated.

Case 6. M. L. (4522), aged seventeen years, was admitted March 27, 1920, with a scoliosis, which had been noticed two years prior to admission and had been slowly increasing in severity. Patient also had had occasional numbness of the legs, more pronounced three weeks before admission. There was no history of injury to the back.

Examination revealed a moderately severe right thoracic curve with wedging of the

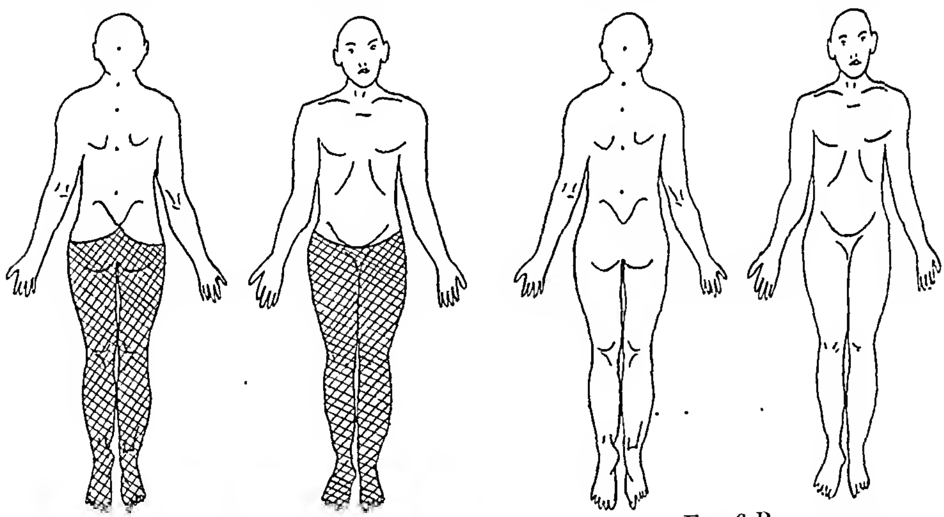

Fig. 6-A Fig. 6-B

Fig. 6-A: Case 6. M. L. (4522), March 27, 1920, aged seventeen, four months before operation, had a moderately severe right thoracic curve with wedging of the fifth thoracic vertebra. Sensory signs had appeared prior to motor.

Cross hatching shows area of anaesthesia.

Gait: There was spasticity, with muscle weakness.

Reflexes: Knee jerk ++++; Achilles tendon ++++; bilateral Babinski; bilateral ankle clonus.

Spinal fluid: Cloudy; fourteen cells per cubic millimeter; protein increased.

Fig. 6-B: Case 6. M. L. (4522), September 13, 1921, fourteen months following operation. There was no evidence of sensory disturbance.

Gait: Normal; no spasticity.

Reflexes: Knee jerk ++; Achilles tendon ++; no Babinski or ankle clonus.

fifth thoracic vertebra. All reflexes of the lower extremities were exaggerated, and there was a bilateral sustained ankle clonus. The disturbance of sensation involved both lower extremities to the anterior superior spines (Fig. 6-A). The case was considered to be a congenital scoliosis with cord involvement.

Treatment consisted of bed rest on a frame with head and pelvic traction. The patient showed very slight improvement under this treatment, which was interrupted because of diphtheria. Four months following admission a laminectomy was performed from the third to the seventh thoracic vertebrae inclusive. There was a distinct kink in the cord observed at the level of the fifth thoracic vertebra. No distinct pressure could be found on passing a probe up and down the neural canal.

After laminectomy there was a rapid improvement, and three months following operation there was a complete recovery from the disturbance in sensation. Fourteen months following laminectomy the patient had no evidence of sensory or motor disturbance, the ankle clonus had disappeared bilaterally, and there was a marked decrease in the previously exaggerated reflexes (Fig. 6-B).

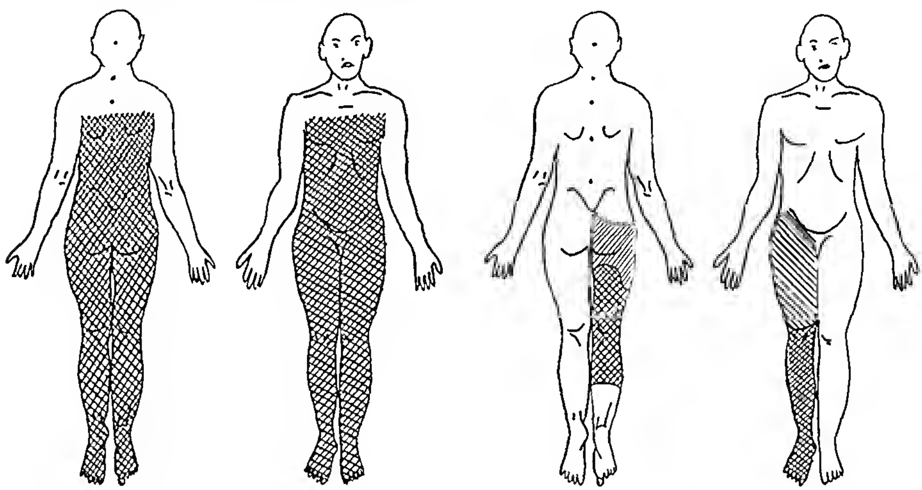

Fig. 7-A Fig. 7-B

Fig. 7-A: Case 7. C. N. (B-9331), November 16, 1927, aged sixteen years, two days before laminectomy, had a left cervicothoracic and right thoracolumbar scoliosis. The motor signs appeared prior to the sensory.

Cross hatching shows area of no sensation to temperature, cotton, and pain.

Gait: Unable to walk; spastic.

Reflexes: Knee jerk ++++; Achilles tendon ++++; bilateral Babinski; bilateral ankle clonus.

Fig. 7-B: Case 7. C. N. (B-9331), December 31, 1927, six weeks following operation. Hatching shows area of diminished sensation; cross hatching, area of anaesthesia.

Gait: Able to walk, but with moderate spasticity of right leg.

Reflexes: Knee jerk ++; Achilles tendon ++; plantar absent, no Babinski; ankle clonus not sustained.

Case 7. C. N. (B-9331), aged sixteen years, was admitted October 21, 1927, with a diagnosis of a left cervicothoracic, right thoracolumbar scoliosis. Because of the wedging of the vertebrae in the cervical spine, the scoliosis was believed to be congenital. The patient's chief complaint was a progressive stiffness of both legs, and the inability to walk. The signs had increased rapidly during the five months prior to entrance. There was a fine fibrillation of the muscles of both legs. The sensory disturbance extended well up on the thorax (Fig. 7-A).

The patient was placed in extension with head and pelvic traction for three weeks, with no change in the neurological signs. A laminectomy was done November 18, 1927, starting at the fourth cervical and ending at the fifth thoracic vertebra. There was no pulsation of the cord below the third thoracic vertebra. There was compression of the

cord at the apex of the cervicothoracic scoliosis. Immediately following the laminectomy, pulsation was noted. Immediately following the operation, there was a loss of bowel and bladder control, which gradually returned to normal.

Patient was discharged February 26, 1928, at which time there was considerable improvement in the sensory disturbance, and bowel and bladder control were normal. The patient started to regain use of the lower extremities one and one-half months following the laminectomy. On July 26, 1930, the patient was walking unaided with only a slight spasticity of the right leg (Fig. 7-B).

CONCLUSIONS

In spite of the brevity of this series of cases of scoliosis complicated by spinal-cord involvement, the following conclusions seem justifiable and are in accord with the literature.

1. The level of the apex of the curve shows no correlation with the distribution of the neurological changes.
2. All motor changes are of the spastic type.
3. There is no definite sequence in the appearance of the sensory or motor manifestations.
4. Conservative therapy shows little, if any, permanent improvement in the neurological status; therefore, laminectomy should be performed if a short period of conservative treatment fails to relieve the signs and symptoms present, or if the neurological signs increase,—whether the sensory or motor changes are in precedence.
5. Laminectomy incisions should be drained.
6. In this series progression of signs and symptoms following laminectomy developed in all patients, but receded after a variable period, except in Case 3. This patient did not regain function.
7. Laminectomy offers the best prognosis in cases of scoliosis with signs of compression, despite the fact that torsion and tension are the etiological factors of these signs.
8. It is desirable to combine fusion with laminectomy when the patient's condition will stand this added operative procedure. The fusion should extend from horizontal vertebra to horizontal vertebra. The combined method of Steindler[5] is a rapid procedure which has proved satisfactory. There may be an increase in the curve if solid fusion is done before the end of the period of rapid growth[6].

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HEMANGIOMA OF VERTEBRAE *

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A great number of articles dealing with hemangiomata or angiomata have appeared in the literature during the past several years. These tumors may occur in practically any tissue of the body. Indeed, when one hemangioma is found, it is not uncommon to find others in other tissues of the same individual. The widespread distribution of these lesions is not necessarily an accurate index of the frequency with which they may give rise to symptoms, for many lesions may be asymptomatic.

REVIEW OF LITERATURE

First recognition of the presence of hemangiomata in vertebrae should be credited to the pathologists of several decades ago. Virchow, in 1863, reported a case in which necropsy in an elderly woman disclosed several angiomata as large as hazelnuts in two vertebrae at a considerable distance from each other; an angioma was also found in the liver.

Claims to priority in reporting the association of paraplegia with hemangioma are conflicting. It seems that Gerhardt was the first to report this association in the case of a youth, aged seventeen years. After an illness of five years, this patient died of erysipelas of three weeks' duration. Necropsy revealed angiomata of the fifth and sixth thoracic vertebrae, and invasion of the spinal canal.

Most writers credit Perman with the first description of the roentgenographic picture of hemangioma of the vertebra. He reviewed the case of a woman, twenty-four years of age, who had paraplegia of two or three years' duration, and described the roentgenographic picture. His patient recovered motor and sensory functions after laminectomy. However, a year earlier Gold had reported a case of paraplegia in which the roentgenographic appearance suggested the presence of a hemangioma. This case was studied at necropsy, but the lesion was not recognized as an angioma by Gold. Bailey and Bucy reported a case, and reviewed the literature to 1929. Their patient, a woman sixty-two years of age, was subjected to laminectomy and roentgenotherapy, and recovery ensued. They stated that to their knowledge the patient was the second to be operated upon successfully, and this statement seems to be borne out by a review of the literature.

Schmorl has given the best summary of the pathological features of

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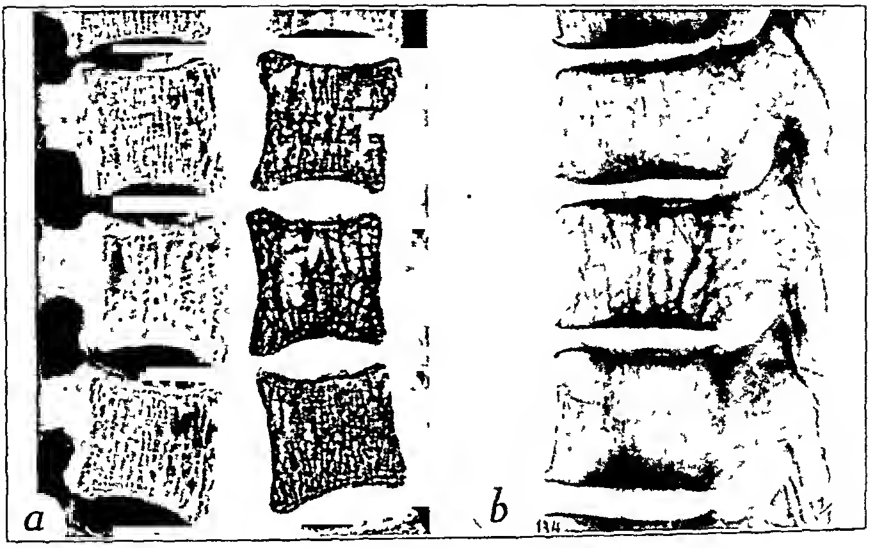

FIG. 1

a: Sagittal section through three vertebrae; the middle vertebra being the site of the hemangioma; *b*: roentgenogram of the same specimen. (*Reproduced by the courtesy of Georg Thieme*[7].)

vertebral hemangioma. In his laboratories vertebrae from 3829 spinal columns were studied, 1948 from men and 1881 from women; and the frequency with which hemangiomata occurred was recorded. Of these 3829 cases, angiomata were present in 409, or 10.7 per cent. In this group of cases, angiomata were found in 8.9 per cent. of the men, and in 12.5 per cent. of the women. In 272, or 66.5 per cent , of the 409 cases only one angioma could be demonstrated in the spinal column. In 134 cases, or 32.8 per cent., two to five angiomata, and in three cases, or 0.7 per cent., even more angiomata could be counted in the vertebral column. In all, according to Schmorl, 579 different angiomata were found in the 3829 spinal columns investigated, of which thirty-two were located in the cervical, 350 in the thoracic, and 170 in the lumbar vertebrae, and twenty-seven in the sacrum. The most frequent sites were the twelfth thoracic vertebra (forty-seven cases), the fourth lumbar vertebra (thirty-eight cases), the first lumbar vertebra (thirty-seven cases), the second lumbar vertebra (thirty-six cases), and the third lumbar vertebra (thirty-six cases).

The majority of Schmorl's angiomata were incidental findings at routine necropsies. They did not have any clinical significance, and were not demonstrable roentgenographically. These tumors may occur in any vertebra, may vary in size, and may be located in different portions of the vertebrae. Schmorl further pointed out that in the pathological specimen the angiomata are recognized by their dark red color. Microscopic studies disclosed that angiomatous tissue grows independently, and thereby destroys the trabeculae of bone. The remaining trabeculae at times become markedly thickened, so that the roentgenographic appearance is that of a field of decreased density, with a few thickened trabeculae of bone, which usually run vertically and parallel at small intervals.

TABLE I

HEMANGIOMATA OF VERTEBRAE ACCORDING TO AGE, SEX, AND LOCATION

Group	Average Age (*Years*)	Patients		Vertebrae Affected																		
				Cervical		Thoracic												Lumbar				
		Male	Female	6	7	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
1	45 6	2	3					2	1					1								1
2	45 0	1	4											1				1		3		
3	45.1	3	6	1				1					1					3	2	1		
4	59 4	6	14			1*			1				1*		2		2	2	6	5	1	
Total	53 0	12	27	1	0	1	0	3	2	0	0	0	2	2	2	0	2	6	8	9	1	1

* One patient had two hemangiomata.

This same type of structure of the spongiosa of vertebrae was seen only once in any other condition, and in that case (a case of metastasizing lymphogranuloma) it was less pronounced. Schmorl, therefore, regarded these columns of bone trabeculae as peculiar and significant to the differential diagnosis of vertebral angiomata. Bailey and Bucy described the roentgenographic appearance of a hemangioma as a "reduction of bone density between parallel trabeculae which are increased in density". This description has been used by others [1].

The question of why some patients have symptoms and others do not has brought out some interesting speculations. According to Schmorl, in cases in which the whole vertebral body is involved by angiomata, some "ballooning" is seen, so that in the lateral roentgenogram the normally indented anterior margins of the vertebral body appear straight or even seem to bulge forward (Fig. 1 *a* and *b*). He assumed, further, that two types of angiomata must be distinguished: (1) the vascular widening of the vertebral bodies which gives an angiomalike formation, and (2) definite neoplasms which have a pronounced tendency to proliferation. However, he stated that present knowledge is too limited to express a final opinion.

Schlezinger and Ungar gave as possible causes of compression of the spinal cord: (1) epidural angioma, present in eight of forty cases reviewed by them; (2) a "blowing" up of the vertebra, caused by thrombosis and oedema associated with osteoporosis and subsequent formation of new bone; and (3) compression fracture of the involved vertebra, which, according to them, is rare,—they found only four cases recorded in the literature. These reasons seem to be adequate explanations for the causes of paraplegia, and perhaps for most of the local symptoms. It is known that some patients may have an extension into the spinal canal and epidural spaces, and that hemangiomata in any situation may at times cause extreme pain, a phenomenon explained on the basis of thrombosis associated with inflammation and swelling. In at least two cases of this

series, a compression fracture was superimposed on the hemangioma Symptoms seemed to date from the compression fracture.

The higher incidence of symptoms among young patients probably indicates an earlier and more extensive hemangiomatous change. It also should be noted that in the authors' patients with compression of the spinal cord by hemangioma, and on whom operation was performed, all but one of the hemangiomata were located in the thoracic vertebrae. This is to be expected, as the cord is larger and the canal smaller in this region.

Schmorl noted that, from the age incidence in his cases, it could be seen that the frequency of angiomata among both men and women increased with advancing age. According to Schmorl, only 3 to 4 per cent of young persons have vertebral angiomata. This percentage increased to 12 for men more than sixty years of age, and to 16 for women of this age. Accordingly, he felt that angiomata seemed to form with advancing age or, if they were actually present at birth, that they progressed in size.

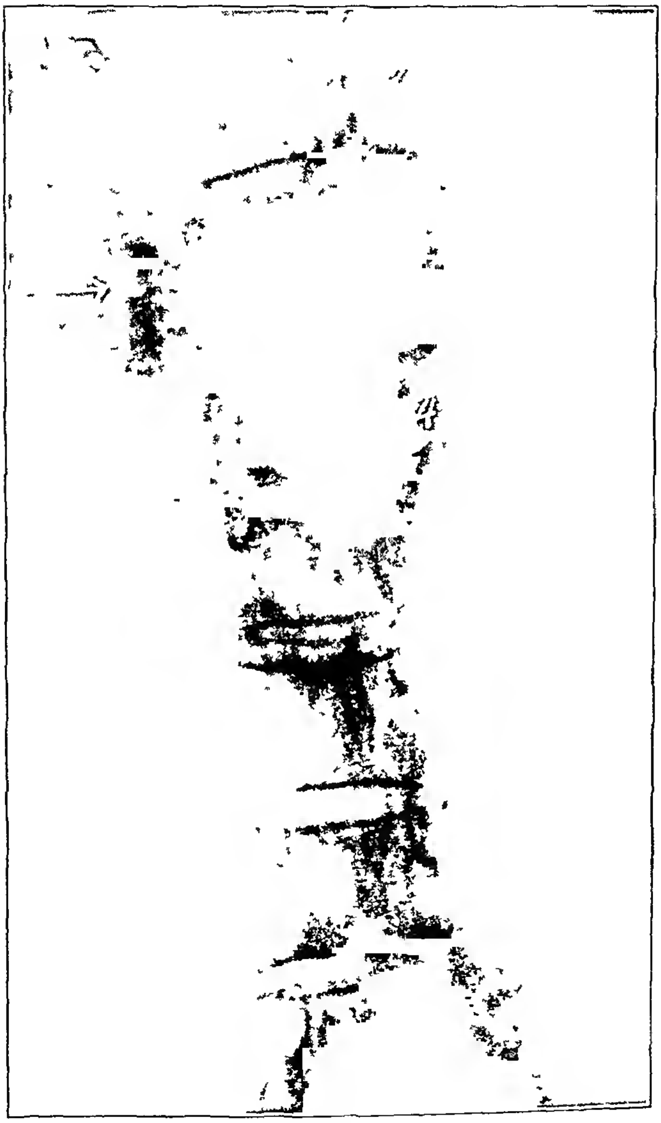

Fig. 2

Hemangioma of the third thoracic vertebra of a woman, aged forty-nine. Symptoms of one year's duration and paraplegia were relieved by laminectomy and roentgenotherapy. The patient is well eight years after operation.

However, the more the literature is reviewed, the more one is impressed with the discrepancies in the statements of various authors. This is probably because the cases fall into four distinct categories: (1) hemangioma with paraplegia; (2) hemangioma with symptoms of

compression of the spinal cord, but without paraplegia; (3) hemangioma with local symptoms and signs, but without evidence of compression of the spinal cord; and (4) hemangioma without any symptoms or signs. The diagnosis in the fourth group is made from the roentgenogram, and the lesion is usually an incidental finding.

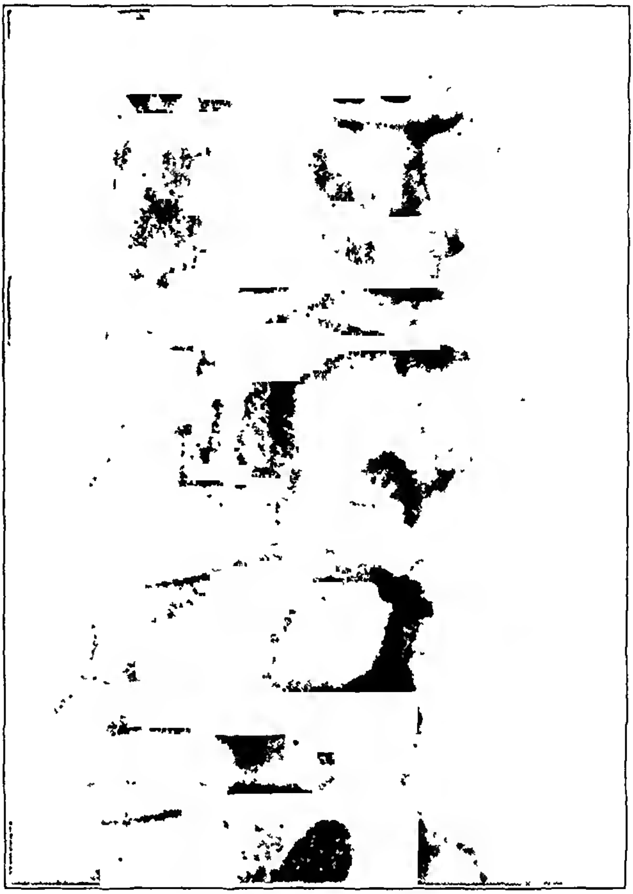

FIG. 3

Roentgenogram shows oblique view of lumbar vertebrae of man, aged forty-four years. Hemangioma is in part of the body of the first lumbar veitebra. His symptoms were minimal.

DATA ON CASES STUDIED

The authors' series consisted of thirty-nine patients, of whom twenty-seven, or 69 per cent., were females, and twelve, or 31 per cent., were males (Table I). This is an even higher percentage of incidence among women than that reported by Schmorl (57.7 per cent.). One of the striking facts brought out in this review is the lower average age of patients who had symptoms. In the first three groups, the average age was about forty-five years, while in the group of patients who did not have symptoms the average age was about fifty-nine years.

Group 1. In the five patients in this group who had hemangioma with paraplegia, operation with or without subsequent roentgenotherapy was the method of treatment. Two patients are dead. One of these died six weeks after operation without improvement; paralysis finally became complete. The other patient, who died six years after operation, had improved markedly and was able to walk. Death apparently was caused by a cerebral accident. One patient improved markedly after laminectomy and decompression, followed by roentgenotherapy. The two remaining patients apparently recovered. Laminectomy was performed on each patient; one also received roentgenotherapy (Fig. 2).

Group 2. In this group are included five patients with hemangioma

in which there were symptoms of compression of the spinal cord, but complete paraplegia was not present. Each patient received roentgenotherapy. A supportive corset or brace also was used in most cases. One patient did not improve. Two improved and two are well, four and six years after diagnosis. Permanent cure is not yet certain, as not enough time has elapsed, but there is no question that these patients improved markedly from roentgenotherapy alone.

Group 3. In this group are included nine patients with hemangioma, in whom the only complaint was that of local pain, and in whom there was no evidence of compression of the spinal cord. In these patients, the hemangioma seemed to be responsible for the symptoms. Seven patients in this group were treated with roentgen rays. For two patients a corset only was used,—in one of these because a medicolegal question was involved. Improvement was not noted in these two cases. Three patients, treated with roentgen rays, have improved, one has been observed for too short a time for the result of treatment to be certain, and the result of treatment of another is not known. Two did not follow the treatment prescribed, and have not improved.

Group 4. The last group included twenty patients in whom symptoms, if present, did not seem to be attributable to the hemangioma (Fig. 3). No follow-up study has been made of this group. Several patients have been examined repeatedly at the Clinic without any evidence of change of status of the lesion being found, but it must be realized that symptoms may develop later.

SYMPTOMS

Localized pain with associated muscle spasm and rigidity of the spinal column are usually the first symptoms to appear in these patients. Other symptoms, such as hyperaesthesia, hypo-aesthesia, radiculitis, and complete transverse myelitis, develop as the severity of the lesion increases. As previously stated, a localized hemangioma may appear as an isolated involvement of the body, pedicle, lamina, or spine, without involving the entire vertebra, and, when such a condition does exist, the nerve roots and the spinal cord may escape injury. However, the lesions which confront the neurosurgeon are those which have resulted from an extensive involvement of the entire vertebra. Nerve roots are frequently impinged by the hypertrophy of the pedicles. Localized, radiating pain is produced, corresponding to the root involved. The crushing, flattening, and ballooning process of the vertebra often results in a sudden motor paralysis of the extremities below the lesion. The paralysis may disappear temporarily on rest in bed and extension, but sooner or later it reappears as the spinal canal is narrowed, and the cord is compressed to such a degree that all function is lost below the level of the lesion.

DIFFERENTIAL DIAGNOSIS

The symptoms produced by cavernous hemangioma of the vertebra are not unlike those produced by an intraspinal tumor, with the exception

that the symptoms develop much more rapidly than those of a benign neoplasm of the cord. The symptoms of a hemangioma of the vertebra probably resemble more the symptoms produced by a metastatic lesion of the spinal column, perhaps with the exception that the metastatic lesions progress more rapidly than those resulting from the cavernous hemangioma. Thus it is extremely important to conduct a thorough general examination, along with the neurological examination, to rule out the possibility of a primary malignant lesion elsewhere. In the early stages of the disease, before complete block in the spinal canal has occurred, studies on the spinal fluid may reveal no abnormality. Lipiodol may flow freely past the diseased vertebrae. As compression occurs, the spinal canal is narrowed and block results in the subarachnoid spaces. This condition is readily recognized by a positive Queckenstedt test,—that is, a failure of the cerebrospinal fluid to rise in the manometer after jugular compression. The spinal fluid may be xanthochromic, and its content of protein is sure to be increased, although the cell count will probably be normal.

Roentgenographic studies of the involved portion of the spinal column usually reveal pathognomonic evidence of the disease. Studies in the earlier phase of the disease will reveal areas of hypertrophy of the pedicle and lamina, enlargement of the intertrabecular spaces, and absorption of trabeculae in the body, with thickening of other trabeculae, thus giving the appearance of channels situated between or interwoven among the trabeculae. In the more advanced stages of the disease, according to Schlezinger and Ungar, a ballooning process takes place, the body of the vertebra is flattened, and the walls have a tendency to bulge. This process accounts for the narrowing of the spinal canal. In a few instances a pathological fracture has occurred, which accounts for the kyphosis or scoliosis.

In reviewing a series of records of patients who had been operated on for a variety of vascular lesions within the spinal canal, it was interesting to note that none of these had an accompanying cavernous hemangioma of the vertebra. The vascular lesions involved were extradural angiomata, subdural hemangiomata, and hemangio-endotheliomata, varices, and arteriovenous fistulas. The laminae were often more vascular than the normal laminae, but in no instance did the roentgenogram reveal evidence of a cavernous hemangioma.

Since the roentgenographic findings reveal pathognomonic evidence of the disease, it is essential that careful roentgenographic study be made in all cases in which the symptoms are suggestive of a cavernous hemangioma of the vertebra. An early diagnosis is essential in order to prevent the pathological fracture of the vertebra and, moreover, the institution of roentgenotherapy will help to prevent the flattening and ballooning process of the body of the vertebra, and the use of a spinal support with corset or brace will eliminate the disastrous result of compression of the spinal cord.

LAMINECTOMY

It was necessary to resort to laminectomy in five patients (Group 1) in whom compression of the cord was present. The procedure is designed to decompress the spinal cord. In no instance was the dura opened. In all cases, excessive bleeding was encountered during laminectomy. In performing the operation, the laminae were found to be hypertrophied and cancellous, and contained numerous and large vascular channels. Bleeding was often so profuse that bone wax would not adhere sufficiently to the rongeured edges of the laminae to control the hemorrhage. It was then necessary to resort to electrocoagulation of the rongeured surfaces of the laminae before applying bone wax. It was also found advantageous to use a bone wax of firmer consistency than that usually employed in craniotomy. In order to facilitate the application of the wax, it was warmed to a soft putty-like consistency before application. Then, as it returned to the temperature of the body, it became firm enough to remain adherent to the channel walls of the raw surfaces of the laminae.

The cord was always found to be compressed from the posterior bulging of the body of the vertebra and the hypertrophy of the pedicles and laminae. The extradural fat was more vascular than normal, but none of it contained true angioma. In one of the five patients a postoperative hemorrhage occurred, so that it became necessary to return the patient to the operating room for evacuation of a soft clot and further hemostasis. Another of the five patients obtained a most satisfactory result for six years, was able to walk about and carry on his regular activities. Then symptoms of compression of the spinal cord again developed. Results of a second operation were unsatisfactory, because complete transverse myelitis had occurred. The recurrence in this instance was undoubtedly due to a progression of the disease in the body of the vertebra, and the failure on the part of the patient to wear an adequate brace. Rhizotomy was performed at the time of the second operation in order to relieve the root pain, since it was impossible to decompress the nerve roots involved without further weakening the spinal support. It is, therefore, apparent that even though laminectomy is resorted to, extreme care should be taken to assure the patient of spinal support. In most instances, a well-fitting Taylor brace or corset with steel back support is sufficient. Although bone grafts have not been used, it is possible that a bone graft applied at the time of laminectomy is a justifiable procedure to assure the patient of the additional support needed to avoid more compression of the vertebrae and a pathological fracture. Roentgenotherapy appears to be indicated in cases in which laminectomy is performed, as well as in those in which it is not performed.

ROENTGENOTHERAPY

Roentgen treatment consisted in application of roentgen rays to the affected vertebra through four posterior fields. Each field received a dose of about 500 roentgen units. The technique was as follows: 135

kilovolts, at a distance of sixteen inches (forty and six-tenths centimeters), five milliamperes, and six millimeters of aluminum filtration. This dose was repeated at intervals of four to six weeks for three to four treatments, and thereafter once or twice a year over a period of four years. The number of treatments depended on the findings on clinical and roentgenographic examination.

SUMMARY

Evidence points toward vertebral hemangioma as a definitely recognizable condition which often does not cause symptoms. However, the symptoms of some patients, particularly the younger ones, may be marked, even to development of complete paraplegia. In such cases laminectomy with decompression, followed by roentgenotherapy, offers the best possibility of relief. In patients in whom paraplegia is not present but in whom there is evidence of compression of the spinal cord or local symptoms, roentgenotherapy is the treatment of choice. Supportive corsets or braces should be used whenever they are indicated,—for instance, with patients who have the static type of pain or sufficient involvement of the vertebra by the hemangioma to cause a pathological compression fracture. This latter complication, however, is rarely noted.

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FRACTURES OF THE TIBIA IN ADULTS

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The purpose of this report is to compare the operative and non-operative treatment of fractures of the tibia in adults, and to analyze the results of treatment of eighty-two tibial fractures out of 354 which occurred among 35,000 cases of trauma of all types during the ten years from 1929 to 1938. Tibial fractures are chosen because of their relatively high incidence. Moreover, they represent serious injuries, take a long time to heal, and involve economic handicap. The work was done by the staff and certain individuals, who for training or other reasons, were attached to the staff temporarily under the direction of William Darrach, M.D., Clay Ray Murray, M.D., and Barbara Stimson, M.D.

In the early period of the organization of the Fracture Service, the open reduction of fractures of the long bones was successful only in so far as an average good general hospital could make it. At that time vanadium steel plates were still being used, and a certain number of surgical tragedies took place when these plates or their screws broke under the vibratory stress of the constant fibrillary movement of muscle tone.

In order to establish a scientific basis for the operative method, experimental work was begun on a stainless steel material, using it on dogs as it would be used physiologically in the operating room. After two years of experimentation, and of the study of its behavior in the tissue and its metallurgy, it seemed that the material was more suitable for fixation of fractures in open reduction than the vanadium steel [1]. Before 1936 only those patients with fractures of the shaft of the tibia were operated upon who could not be adequately treated with other methods. After that date, in consequence of these experiments, all fractures of the shaft of the tibia, except those involving the cancellous portions of the condyles and the cancellous portion about the ankle, were considered primarily as operative cases, and were treated as emergencies.

The material analyzed in Table I is subdivided into three groups:

From 1929 to 1931 inclusive, the Fracture Service was in its formative period, and the conservative, non-operative methods then in prevalent use were utilized in the majority of cases. It should be remembered that even in this period the senior members of the staff already had a collective experience of handling fractures, beginning in 1901, which if not optimum was certainly adequate. In this early period there were twenty-six cases suitable for analysis. Nine were treated operatively and seventeen by closed methods.

During the period 1932 to 1935 inclusive, there was a wider applica-

tion of the operative method. Furthermore, the overlap from the general surgical divisions was considerably reduced as far as temporary personnel was concerned. In the group treated during this period there were twenty-seven patients. Of these, thirteen were treated by open reduction and fourteen by closed methods.

During the period 1936 to 1938 inclusive, the Fracture Service had evolved to its present form, and operative fixation of fractures had been adopted as the method of choice. Twenty-nine cases are considered in this group, twenty-three of which were treated by operative fixation and six by closed reduction.

Thus in the three groups, the proportion of patients operated upon to those not operated upon was nine to seventeen for 1929 to 1931 inclusive, thirteen to fourteen for 1932 to 1935 inclusive, and twenty-three to six for 1936 to 1938 inclusive.

BASIS OF STUDY

Standards for Follow-up. It is worth emphasizing that of all the cases seen in this Clinic, 90 per cent. are followed in some way. However, in this analysis only those cases which have gone to complete restitution, or have reached a stationary level for at least a year, are to be considered. Moreover, only cases are considered for analysis in this series for which the charts contain adequate and full notes on the periodic evaluation of the patient with regard to anatomical, physiological, and economic status. Records of cases included also contain enough of the history of the injury, the course of rehabilitation, and the personality as a whole to allow some conclusion to be drawn as to whether or not compensation or liability, if present, affected the period of rehabilitation. This has resulted in the selection of only eighty-two cases out of a total of 354 patients of all ages with fractures of the tibial shaft.

A better conception of the types of cases included in this analysis, aside from the adequacy of the follow-up, may be gained by mentioning some of the reasons for the exclusion of cases.

Reasons for Exclusion of Cases from Analysis. Of the 272 patients not included in the analysis, 180 were under eighteen years of age. These are not included because it is well known that fracture healing in the young has an entirely different course from that in the adult. Others are excluded because the records are inadequate for the data required, the follow-up was incomplete, or the fractures involved the upper or lower cancellous portions of the tibia, or were pathological. Those patients with multiple fractures, which make adequate evaluation of the fracture of the tibial shaft impossible, those who died from causes not connected with the method, and those who were first seen weeks or months after the injury, are also excluded.

Criteria for Evaluation of Healing. The determination of bony union is based on (1) roentgenograms, (2) clinical evidence, and (3) the ability of the patient to bear full weight without any external support. While

these are the criteria of bony union, many patients were able to return to work long before it was established. Some of these, in whom the fracture was simple and uncomminuted, and in whom rigid internal fixation was possible, returned to sedentary work in from one to two months, either in walking boots or weight-bearing calipers which usually extended only to below the knee, though occasionally included a thigh cone.

Definition of Method. Under the term "closed method" are included all procedures such as manipulative reduction with application of plaster, skeletal traction with suspension, double-wire fixation either in traction or with the application of plaster, and any other type of treatment short of operation. Under the term "operative treatment" are included cases of both simple and compound fractures, treated by open reduction with or without internal fixation.

Concomitant with the development of the Service by improvement in technique and observation of cases, operative fixation of fractures has come to be considered adequate only when rigid enough to allow mobilization of the contiguous joints as soon as, or even before, the operative wound is healed. Operative fixation was adopted as a method of choice in the fall of 1935.

ANALYSIS OF CASES

From the point of view of time required for union by the criteria previously mentioned, the following arbitrary standards are laid down:

1. Those cases in which bony union was established in six months are considered as being within physiological limits of healing.
2. Union by seven months to a year is considered as delayed.
3. Delay beyond a year is considered as non-union, even though ultimate healing occurred after that time.

The healing time for the patients who were operated upon for either compound or simple fractures was distinctly shorter than for those who were treated conservatively. This of course was not always true if a delay of several days or more took place between the injury and operation.

There were many factors which determined whether or not union occurred in a particular case. There were circumstances which make understandable the group of delayed unions in the early period, as well as the group of non-unions. Moreover, there were conditions and influences which were so complex and imponderable that proper evaluation of them would exclude enough cases to render this series unsuitable for analysis,— the time factor, the psychological status of the patient, that is, whether or not the patient was eager to get up and about and back to his work. For example, there were compensation cases which grew into cases of malingering, and some patients even caused self-inflicted wounds to delay soft-part healing. Other important considerations were: the period between injury and hospitalization, the type of emergency treatment given, the nature of the fracture itself, the importance of the accompanying soft-part involvement, and the infinite nuance in circumstances

TABLE I — TREATMENT AND RESULTS

Year	Union (*Months*)			Delayed Union (*Months*)						Non-Union (*Years*)				
	4	5	6	7	8	9	10	11	12	2	3	4	5	6	9
1929	cl. cl. cl. op. fx.	cl. cl.		cl.			cl.			cpd. ofx. cpd. ofx.	cl.				
1930	cl.	cl. cl. cl. cl.	cl.	cpd. ofx.								cpd. ofx.		op. fx.	
1931	cl. cl. op. fx. op. fx.	cl.	cl.												
1932	cpd. ofx. cpd. fx.	op. fx.											cpd. ofx.		
1933		cl. cl. cl. cpd. ofx.	cl. cl.							cpd. fx.					cl.
1934	cl. cl. op. fx.	op. fx. cpd. ofx.	cl. cl.		cl.										
1935	op. fx. op. fx.	op. fx.	cl. cl.		cl.								*cpd. fx.		
1936	cl. cl. cl. op. fx. op. fx.	cpd. ofx. cpd. fx.	op. fx. cpd. fx.		cpd. fx.										
1937	op. fx. op. fx. op. fx. op. fx. cl.	cl. op. fx.	op. fx.	cpd. fx.											
1938	op. fx. op. fx. op. fx. op. fx. cl.	op. fx. op. fx.	op. fx. cpd. fx. cpd. fx.												

cl. = Closed reduction of simple fracture.
op. fx. = Operative fixation of simple fracture.
cpd. fx. = Compound fracture with internal fixation.
cpd. ofx. = Compound fracture, with no internal fixation.
* With loss of substance in five years.

TABLE II

Distribution of Cases Treated by Operative and Non-Operative Methods

Year	Suitable for Analysis		Unsuitable for Analysis			Total
	Open	Closed	Open	Closed	Deaths	
1929	3	8	1	22	0	34
1930	3	6	1	18	1	29
1931	3	3	0	31	1	38
1932	4	0	0	25	0	29
1933	2	6	1	25	0	34
1934	3	5	0	15	0	23
1935	4	3	0	30	2	39
1936	7	3	0	39	6	55
1937	7	2	0	28	1	38
1938	9	1	0	25	0	35
Totals	45	37	3	258*	11	354

* This figure includes 180 patients under eighteen years of age.

which had direct or indirect bearing on the course of the disease or the recovery.

The cases shown in Table I are well scattered, from healing at four months to non-union. This includes patients treated operatively and non-operatively. It is worthy of note that although there are nine cases of non-union out of the fifty-three up to 1936, there have been none in twenty-nine cases since 1936. There is a distinct trend away not only from delayed unions, but from non-unions as well. For example, from 1929 to 1935 inclusive, four closed reductions resulted in delayed union. Another delayed union was in a patient whose compound fracture was treated without internal fixation. However, of the cases treated since 1936, only two have resulted in delayed unions. In one of these there was ample reason for slow healing. It was a badly injured limb with marked soft-part involvement and loss of bony substance. In fact, in attempting to restore length to the limb, corner-to-corner contact was all that could be obtained. A plate was used to bridge the gap and hold length, but cross fixation was impossible. The fixation held only temporarily, because infection followed the marked soft-tissue involvement, and the screws holding the plate pulled out. At three weeks a Kirschner wire was put through the os calcis and incorporated in the plaster, in order to maintain the position and length originally obtained. Actually, this case cannot be counted against internal fixation of compound fractures, because, aside from the loss of bony substance and the presence of infection, the internal fixation was only partially and, even then, temporarily, effective.

For comparison, there are twenty-seven cases from 1936 to 1938 inclusive. Fifteen healed in four months. Five patients were treated

by closed methods, and ten were operated upon and had internal fixation.

The six patients in whom healing took place in five months, with the exception of one who had a closed reduction and one who had a compound fracture, were all operated upon, and internal fixation was used. The patient with the compound fracture, although operated upon, did not have internal fixation, because of lack of displacement and a small compounding wound.

The six patients who were healed in six months were all operated upon, and had internal fixation. These included three with compound injuries.

Observe that up to 1936, sixteen patients out of thirty-nine were healed in four months. These were *almost equally divided between patients who were operated upon and those who were not.* In the later group, from 1936 to 1938 inclusive, fifteen patients out of twenty-seven were healed in four months, *ten were operated upon and five were not.* Again, in the early group of patients, thirty-nine were healed in six months. However, *in this same period there were also fourteen cases of delayed or non-union.* In contrast, the later group of twenty-seven patients were healed in six months, but in the same period there were only two cases of delayed union.

It may seem that the series of cases analyzed is too small to warrant a definite conclusion. However, it must be emphasized that in the selection of material, a rigorous standard for follow-up was applied.

The cases used in this series contrast the end results in operative and non-operative treatment of fractures. The non-operative methods have already been mentioned, and include those in prevalent use. The operative treatment is adequate for comparison only when rigid internal fixation is attained. The methods used to accomplish this have been considered elsewhere [2]. This improved operative method together with the fact that the operative method was used more generally from 1936 on, instead of being limited to emergency cases, doubtless influences the comparison.

On this Service, at present, fractures of the tibial shaft in adults are considered emergencies, and the patients are operated upon as soon after the injury as surgical and medical evaluation is made,—that is, within an hour or two. In a simple case, which is treated early and where rigid internal fixation is attained, the period of hospitalization may be two weeks. Weight-bearing is expected in between one and two months, though the extremity is protected by a walking boot or weight-bearing caliper below the knee, and very occasionally a thigh cone. Solid bony union is usually attained within four months.

In compounded cases, hospitalization is usually longer, and is determined in part by whether or not infection supervenes. When it does not, the wound is allowed to close or may be treated by pinch grafts at intervals of two or three weeks. In these as well, bony union is expected in four months or soon thereafter.

Where the compounding is complicated by infection, the axis and length of the bone are retained, and bony union follows at a slightly slower rate, usually within six months. The infection seldom spreads.

To date, there has been no loss of limb or life attributable to the open method, despite the fact that as yet none of the newer drugs, such as sulfanilamide, has been used as a prophylactic against infection.

SUMMARY AND CONCLUSIONS

The results of the operative and non-operative treatment of fractures of the tibial shaft in adults over a period of ten years have been compared. The concrete basis for the evolution of a surgical perspective under the conditions existing and under a continuity of organizational guidance has been studied.

Based upon the analysis of the cases considered, the operative treatment of compound or simple fractures of the tibia in adults, gives a surer course and better results than do the non-operative methods.

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OSTEOCHONDRITIS DISSECANS OF ANKLE JOINT

The Use of Tomography as a Diagnostic Aid

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The term "osteochondritis dissecans" was coined in 1905 by König; however, Alexander Munro as early as 1738 recognized the condition. This diagnosis is used to denote a disease of obscure origin, characterized by the demarcation and detachment of one or more fragments from the articular cartilage and underlying bone of some joint surface. Pathologically, osteochondritis dissecans is an aseptic necrosis of bone, the inception of which is frequently associated with trauma. For discussions of the various theories of etiology of this condition the reader is referred to the bibliography accompanying this article.

According to Conway more than 85 per cent. of the reported cases describe this disease as it affects the knee joint; the elbow seems to be next in point of frequency. Relatively few cases of involvement of the hip, metatarsophalangeal, or ankle joint have been reported. In the literature at their disposal, the authors have been able to review but seventeen cases of osteochondritis dissecans of the ankle joint, and to their knowledge there are reports of but two other established cases, the published accounts of which, unfortunately, have not been accessible to them.

Most of these cases occurred in young adults, and in virtually all there was a definite history of trauma. The most constant symptom was pain in the ankle, usually coming on after prolonged standing or walking. In light of the paucity of the literature on the subject, it is felt that osteochondritis dissecans of the talus is certainly not of common occurrence, and that it is justifiable to add another case to the reported series, supplying a bibliography to the other authenticated cases on record. The case reported below is of especial interest in that the diagnosis depended upon the use of tomography, as conventional roentgenograms of the joint were negative.

CASE REPORT

F. H., a lumber clerk, aged thirty-four years, was seen by one of the authors (M. C. M.) eight months after he had sustained an injury to the right ankle joint, resulting from an eight-foot fall from a platform. The patient had landed on both his feet, breaking the fall with his hands. Immediate total disability resulted in the right ankle, and roentgenograms revealed a chip fracture of the anterior aspect of the distal end of the right tibia, involving the internal malleolus. Plaster immobilization was applied and retained for eight or nine weeks, and was followed by physiotherapy. The patient returned to light work.

The past history was essentially negative, with no specific bone injury or previous joint disability relative to the right ankle.

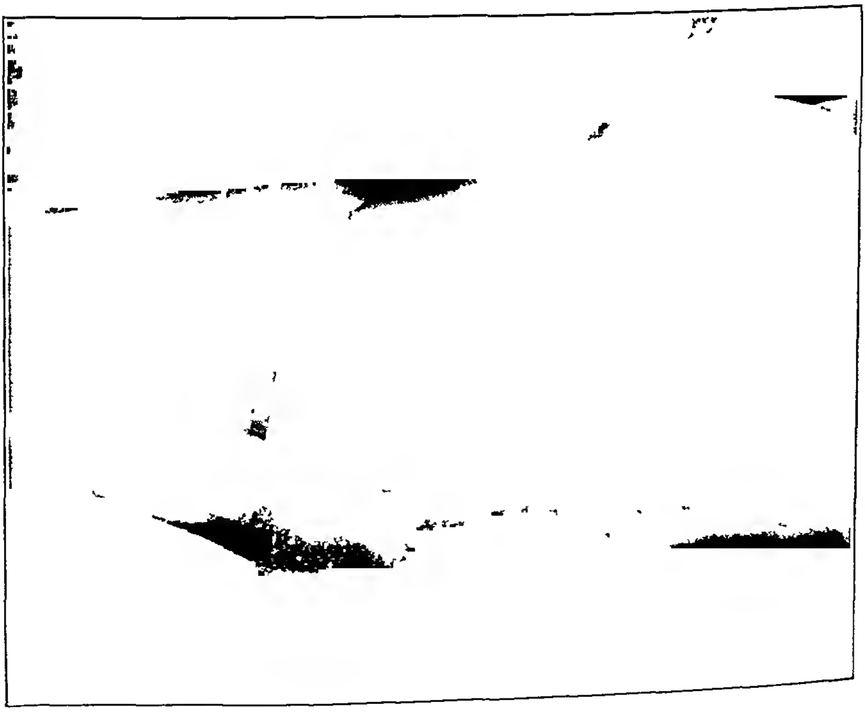

Fig 1-A

Conventional roentgenogram, anteroposterior projection, taken November 28, 1940, shows normal appearing talus and tarsal bones.

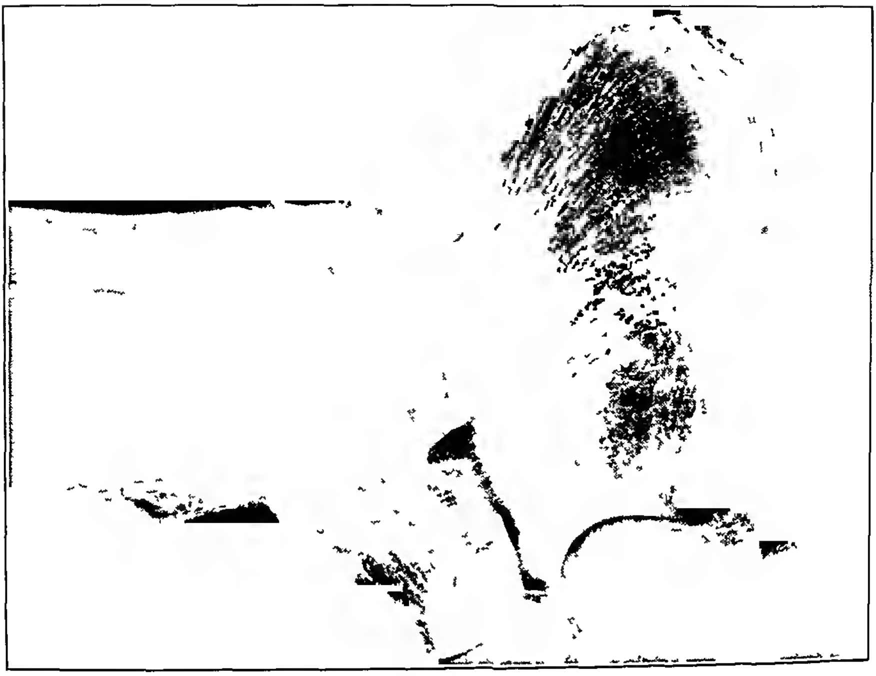

Fig 1-B

Conventional roentgenogram, lateral projection, taken November 28, 1940, shows no evidence of osteochondritis dissecans tali

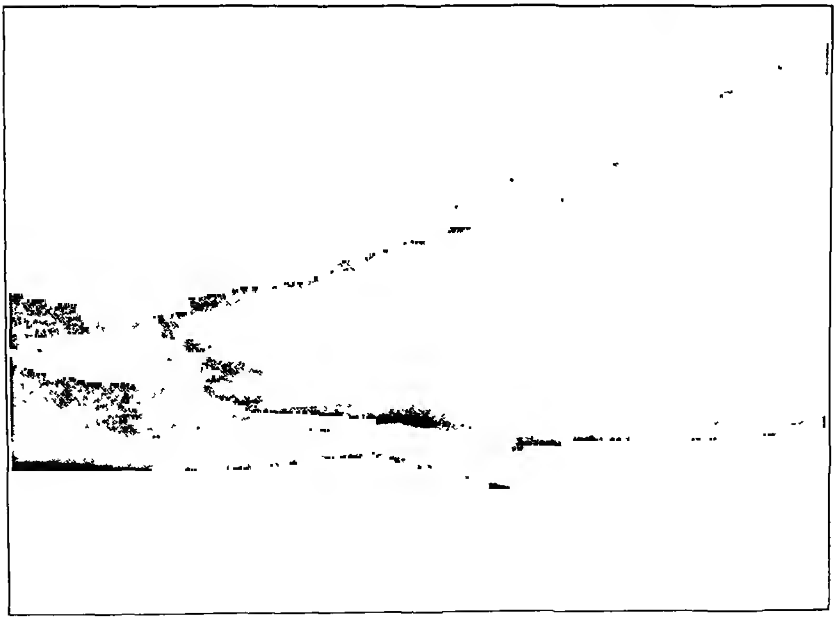

FIG. 2-A

Tomogram, anteroposterior projection, taken December 4, 1940, shows osteochondritic process on the superior articular surface of the talus.

FIG. 2-B

Tomogram, lateral projection, taken December 4, 1940, localizes the loose fragment of bone displaced from the posteromesial aspect of the talus.

When seen, the patient complained of an occasional recurrent pain in the right ankle, localized mesial to the internal malleolus, unrelated to activity, and not relieved by rest. There was no tenderness anywhere about the ankle. The patient also stated that there was recurrent giving way of the right ankle inwardly, sufficient at times to cause the patient to fall. There had been numerous episodes of "slipping" of the right ankle, unaccompanied by loss of balance.

Examination

The patient carried a cane, and on discarding it walked with an intermittent limp, but on a good base. He placed his foot flat on the floor with loss of the natural spring. He rose and walked well on his toes. In the squatting position, he complained of discomfort over the anterior aspect of the ankle joint, and difficulty in dorsiflexion of the right ankle. Weight-bearing statics revealed bilateral flattening of the anterior arches, and the right foot showed a mild cavus and claw-toe deformity. There was some mild apparent thickening in the space in front of the Achilles tendon, and prominence of the external malleolus on the right.

Circumferential measurements six inches below the patella were twelve and three-quarters inches on the right and fourteen and one-quarter on the left; the bimalleolar measurements were ten and one-quarter inches on the right and ten and one-eighth inches on the left; and the mid-tarsal measurements were ten and one-quarter inches on the right and ten inches on the left.

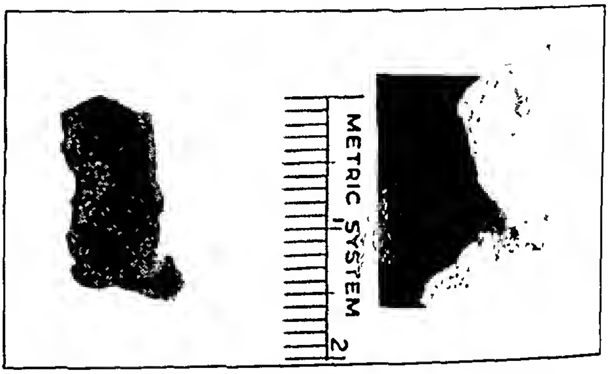

Fig. 3

Photograph of the osteochondritic body removed from the superior articular surface of the talus.

Foot Motions: Dorsiflexion was limited to 4 degrees, and plantar flexion to 14 degrees. Inversion was slightly limited when compared with the left foot; and eversion was limited 35 per cent. Forced passive inversion referred pain mesial to the internal malleolus. There was no peroneal pain complained of at this time.

Reflexes: Knee and ankle jerks were equal and active. Inspection of patient's shoes disclosed equal wear on analogous locations on both shoes.

Roentgenograms: Conventional roentgenograms of the right ankle, taken March 26, 1940, showed an irregular compression deformity of the tibial cortex just proximal to the ankle joint, with a comminuted fracture of the tip of the internal malleolus. There was no evidence of bone injury in any of the tarsal bones. Subsequent roentgenographic study of the talus and ankle joint on November 28, 1940 (Figs. 1-A and 1-B), showed good healing of the fractures previously reported, and no evidence of demonstrable injury to the talus or other tarsal bones. On December 4, 1940, tomograms were made of the right ankle in the anteroposterior and lateral projections (Figs. 2-A and 2-B), and with the plane passing through the ankle parallel with the plane of the ankle joint. These examinations showed the presence of a loose fragment of bone displaced from the posteromesial aspect of the talus, and measuring approximately one by two centimeters in length by five-tenths of a centimeter in thickness. The fracture of the anterior end of the tibia near the joint surface was healed.

Diagnosis

A definite diagnosis of a loose body in the right ankle joint was made, for which arthrotomy was recommended and subsequently carried out.

Operation

On December 27, 1940, at Stanford University Hospital, an arthrotomy of the right ankle joint was performed through a posterior approach. On the posterosuperior margin of the talus, as demonstrated by the tomogram, a definite "joint mouse", about one by two centimeters, and irregular in character, was found loosely adherent by fibrous tissue to the articular surface of the talus. This was dissected free and removed (Fig. 3). Further inspection of the dome of the talus revealed several irregularities in the articular cartilage, and a definite defect in the bone where the "joint mouse" was removed; this was replaced by fibrous tissue to some extent. The capsule and other layers were closed with interrupted silk sutures, and a dry compression dressing was applied.

Postoperative Course

No immobilization was applied postoperatively and the surgical wound healed *per primam*. He was discharged on January 14, 1941, ambulatory, and was not using a cane. Subsequent to this date the patient reported to the office for rehabilitation therapy, consisting of heat, massage, and graded exercises, including bicycling.

By March 14, 1941, sufficient recovery had ensued to allow the patient to return to his original occupation. There had been no further episodes of joint instability, and his subjective complaints were confined to generalized soreness in the ankle region. For two weeks prior to discharge the patient had been able to engage in tennis matches without disability other than fatigue. Objective examination revealed the persistence of loss of 4 degrees in dorsiflexion and of 7 degrees in plantar flexion. Inversion and eversion were free and unrestricted. There was no tenderness present in the area about the ankle joint.

DISCUSSION

The case reported is mainly of interest because of two factors: First, it is another established instance of osteöchondritis dissecans of the ankle joint; second, it illustrates the value of tomography in the roentgenographic diagnosis of lesions of the osseous system, and emphasizes its importance in the accurate localization of bone defects requiring operative intervention. By this means it is possible to plan preoperatively the most direct approach whereby the lesion can be reached with a minimum of trauma to the surrounding structures.

Tomography (from Greek: *temnein*, to cut; plus Greek: *graphein*, to write) is one of the several methods of body-section roentgenography, which embraces tomography, planigraphy, stratigraphy, laminagraphy, and vertigraphy. For detailed accounts of these special roentgenographic methods the reader is referred to the articles by Andrews, Grossmann, Moore, Kieffer, and Twining. The basic principle of body-section roentgenography is that by the synchronized movement of the x-ray tube and film, during exposure, about the pivot point or body section to be visualized, roentgen shadows, which otherwise would interfere with obtaining a clear and truthful reproduction of the desired plane, are eliminated, whereas the desired plane or pivot is constantly being focused on the same fixed point on the film, so that it alone is clearly and truthfully reproduced on the roentgenogram.

Shadows of objects farthest from the desired plane are most blurred, whereas those in close proximity to the selected plane are least blurred. The tomograph, introduced by Grossmann in 1935, is an extremely satis-

factory device for accomplishing body-section roentgenography. Twining, in 1937, proposed a method of carrying out tomography by means of a simple attachment to the Potter-Bucky table.

Tomography is certainly not recommended as a substitute for conventional roentgenography, but rather as an addition to the armamentarium in roentgenographic diagnosis. To be sure, ordinary roentgenograms should be carried out as indicated in the individual patient, but in the event that conventional roentgenograms are not diagnostic, and there is clinical evidence suggestive of morbid changes in the skeletal system, every effort should be made to obtain tomographic visualization of the part under suspicion.

SUMMARY

The publishing of this case brings the total number of reported instances of osteochondritis dissecans of the ankle joint to twenty. The importance of tomography in the diagnosis and localization of obscure lesions of the osseous system is emphasized.

CONCLUSIONS

1. Although but twenty established cases of osteochondritis dissecans of the ankle have been reported, the condition will probably be more frequently detected if tomography is carried out in suspected cases, despite negative findings by conventional roentgenography.
2. In the case reported, the causal relationship between the trauma sustained and the development of osteochondritis dissecans seems inescapable. This conforms to the general opinion relative to trauma as an etiological factor in the production of this disease entity.
3. Chronic pain or discomfort in the ankle—following a sprain, dislocation, or fracture—which persists despite ordinary conservative treatment, should suggest the possibility of osteochondritis dissecans tali.
4. A history of recurrent instability of the ankle should arouse suspicion relative to the possibility of a loose fragment or "joint mouse".
5. The treatment of choice is arthrotomy, with removal of the loose fragment or fragments, but without immobilization. This should be followed by rehabilitation therapy in the form of diathermy, massage, and graded exercises, which are important adjuncts in the accomplishment of prompt postoperative recovery of normal function and complete rehabilitation.
6. Prognosis is excellent in patients receiving early diagnosis and appropriate treatment. Such treatment is also a prophylaxis against the development of chronic hypertrophic synovitis and traumatic arthritis.

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THE TREATMENT OF OBLIQUE, SPIRAL FRACTURES OF BOTH BONES OF THE LEG

An Analysis of Fifteen Cases Treated by Open and Closed Methods

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Fractures of both bones of the leg are frequently seen, particularly in Marine Hospitals whose patients as a rule have been employed in hazardous occupations. The material submitted is taken from the clinical records of the fractures treated during the fiscal year 1939, in the U. S. Marine Hospital, Detroit, Michigan. The fractures included are only those of the type described below. Fractures near a joint, badly comminuted fractures, and transverse fractures are not included, as they would not allow a fair comparison. After the elimination of these types, fifteen patients remained, seven of whom were treated by closed methods and eight by open methods.

The diagnosis "fracture of both bones of the leg" includes, of course, fractures in many locations and of diverse types. There may be fractures of the shaft, fractures about the knee, or fractures about the ankle. Each of these has some peculiar clinical characteristic which influences treatment.

The fracture with which this discussion is concerned is almost a clinical entity. It is a fracture of the shafts of both bones occurring somewhere in the middle three fifths. In the tibia it is oblique and spiral in type and this is an important factor in its treatment. It may be single or comminuted. The fibula is usually fractured at a different level and in a great proportion of the cases is comminuted. It may be oblique or transverse. The fracture of the fibula is unimportant, however, and needs no special attention. Union of the fibula occurs quite readily if the tibia is properly reduced and fixed. Indeed, it often bridges large open gaps to secure good solid union.

The criteria of good treatment in these fractures are the same as in any fracture,—namely, the accurate apposition of the bone ends in as physiological a position as possible, and complete fixation in this position until union has occurred. It is believed that even a minimal movement of the apposed fragments is conducive to delayed union, a factor which has made fracture of the surgical neck of the femur so refractory to treatment until recently.

The open method of treatment of such fractures, as opposed to the various methods of closed treatment, seems logical for the following reasons: (1) Under direct vision an oblique, spiral fracture can be more readily and more accurately reduced. (2) In these oblique fractures, because of the sharp ends of the fragments, there is very often interposed soft tissue consisting of muscle or fascia or both. (3) More rigid fixation can be obtained by internal fixation.

It appeared that, in general, the results in this type of fracture were not satisfactory. Who has not seen such a fracture with non-union many months after its occurrence, or a malunion producing decided disalignment in the weight-bearing line, which brings with it chronic foot strain or a traumatic arthritis of the ankle and foot joints? In those cases in which the clinical results were good, it appeared that too long a time elapsed between the injury and the patient's return to work. A normal bone, after fracture, placed in good apposition, should show union with beginning deposition of calcium salts in five to six weeks, and solid callus in eleven to twelve weeks.

A critical survey, therefore, was undertaken of the cases with which the author had had personal contact, to find out whether, as was believed, the open procedure was productive of better clinical results in a shorter time, and was more economical to the patient and the hospital.

The findings are tabulated in Tables I, II, and III.

Table I gives data on fractures treated by closed methods. These methods are:

1. Manual reduction of the fragments and fixation by the application of a plaster dressing.

2. The insertion of Steinmann pins above and below the fracture. With the aid of the pins the fracture is manually reduced, and, while held in this position, a cast is applied incorporating the pins, thus securing better fixation than in the first method.

3. The use of some type of frame, such as the Roger Anderson or Braun frame. In this method pins are inserted in the bone as in the second method. These are attached to the parallel bars of the frame in such a way that they may be moved in any direction, and can be locked in the desired position. After a suitable time the leg is encased in a plaster dressing.

4. The use of continuous skeletal traction and the later application of a cast. This method embraces much the same principle as the frame, but the fixation is not so rigid.

As previously stated, the tibia alone is the object of treatment.

Table II gives data on the fractures treated by the open method. This consists of reducing the fractures under direct vision and internally fixing them by wire sutures, metal plates, screws, nails, or bone grafts.

After appropriate preparation, a semilunar incision is made on the anteromedial aspect of the leg over the fracture site, with the convexity directed posteriorly. The fracture site is exposed by dissecting back the skin flaps. The fracture is reduced by traction and manipulation and held in position by means of bone clamps. At this stage the reason for so many non-unions in this type of fracture is seen. In 60 per cent. of the author's patients, who were operated upon, muscle or other soft tissue was found interposed between the fragments, the sharp end of one of the fragments having speared the soft tissue. Obviously, when this situation

TABLE I

CLOSED TREATMENT OF FRACTURES OF BOTH BONES OF THE LEG

Patient	Date of Injury	Method of Treatment	Date Ambulant without Support	Total Days from Injury to Ambulant Status	Total Days Lost from Work	Hospital Days	Total Days under Treatment	Results	Complications
J. M. (11616)	Apr. 21, 1938	Steinmann pins, Böhler splint	Oct. 8, 1938	170	210	27	224	Medial angulation with disturbance of weight-bearing line	
M. H. (11684)	Apr. 29, 1938	Manual reduction and cast	Dec. 1, 1938	216	216 Clerical work	43	216	Posterior and lateral angulation disturbing weight-bearing line	Delayed union
H. P. (12100)	Nov. 26, 1938	Steinmann pins in cast after manual reduction	Apr. 4, 1939	129	216	229*	260**	Alignment good. Union good	Large indolent ulcer from long-continued cast pressure
F. P. (8589)	Dec. 1, 1938	Steinmann pins in cast after manual reduction	Not ambulant Sept. 30, 1939	303+†	303+†	21	303+†	Non-union. Lateral deviation of lower fragment disturbing weight-bearing line	See results
A. G. (12034)	Dec. 31, 1938	Manual reduction and cast	June 8, 1939	159	203	161	161	Slight anterior bowing. No disturbance of weight-bearing line	Delayed union
T. H. (12579)	Feb. 3, 1939	Skeletal traction	May 26, 1939	112	182	79	112	Good	None
C. Mc. (12635)	Feb. 15, 1939	Skeletal traction	May 25, 1939	99	106	39	100	Good	None

* This figure includes thirteen extra days incurred because of an indolent ulcer.
** This figure includes forty-four additional days' treatment because of ulcer.
† This patient is still ambulant only with the aid of a brace and crutches, and is still not working, though fit for some work. September 30 was chosen as the date on which it was definitely decided that closed treatment was of no avail. The patient has consistently refused open reduction.

TABLE II

OPEN TREATMENT OF FRACTURES OF BOTH BONES OF THE LEG

Patient	Date of Injury	Date of Operation	Date Ambulant without Support	Total Days from Injury to Ambulant Status	Total Days Lost from Work	Hospital Days	Total Days under Treatment	Highest Post-operative Pulse	Highest Post-operative temperature (*Degrees Centigrade*)	Results	Complications
L. F. (11087)	Feb. 26, 1938	May 27, 1938	Sept. 4, 1938	100*	198*	37*	168*	110	39 0	Good	None
H. H. (8679)	Dec. 20, 1938	Feb. 6, 1939	Apr. 30, 1939	83*	116*	53*	116*	110	38.3	Good	None
S. B. (12168)	Feb. 3, 1939	Feb. 15, 1939	May 24, 1939	110	170	25	160	108	38 2	Good	None
A. P. (8801)	Feb. 10, 1939	Feb. 13, 1939	Apr. 24, 1939	73	130	65	130	94	37 5	Good	None
L. D. (12275)	Mar. 7, 1939	Mar. 8, 1939	May 28, 1939	82	146 †	21 †	146†	110	38.4	Good	None from fracture †
A. S. (8930)	Mar. 19, 1939	Mar. 24, 1939	May 26, 1939	68	117	16	101	100	37 8	Good	None
J. C. (12440)	Apr. 12, 1939	Apr. 12, 1939	June 24, 1939	73	133	31	133	110	38 6	Good	None (compound fracture)
W. Y. (12683)	June 1, 1939	June 2, 1939	Sept. 11, 1939	102	132	26	122	96	37.4	Good	None

* For the purpose of this table, time of injury is taken as time of operation. L. F. (11087) had no union after ninety days following closed reduction, and at operation muscle and fibrous tissue were found interposed between the fragments. H. H. (8679) had no union or signs of union after thirty days following closed reduction, and at operation tissue was found interposed between the fragments.

† On August 1, 1939, patient developed an extraneous infection which prevented actual return to work, and required an additional thirty-two days of treatment, eighteen of them in the hospital, but this was not related to the fracture in any way. As far as the fracture was concerned, he was fit for duty.

TABLE III

COMPARISON OF OPEN AND CLOSED METHODS OF TREATMENT

Method of Treatment	Average Time from Injury to Ambulant Status	Average Time Lost from Work	Time in Hospital	Average Time under Treatment	Poor Clinical Results (*Per Cent.*)	Complications (*Per Cent.*)
Closed. .	169.71 days (5.7 months)	205.14 days (6.8 months)	85.57 days (2.8 months)	196.57 days (6.6 months)	43	57
Open. . . .	86.37 days (2.9 months)	142.75 days (4.8 months)	34.25 days (1.1 months)	134.50 days (2.1 months)	0	0
Difference. .	83.34 days (2.8 months)	62.39 days (2.0 months)	51.32 days (1.7 months)	62.07 days (2.1 months)		

exists, it would be almost impossible to secure reduction of the fragments by closed methods.

With the fracture firmly held by bone clamps, small drill holes are made in each fragment through which silver wires are introduced. By wrapping the silver wire sutures about the bone and twisting them, the fracture is securely immobilized. The fragments cannot flare; and because the wires run through, vertical sliding is prevented. On two occasions metal plates were used, and on another occasion a bone graft was employed, but in the usual case the wire suture suffices.

The incision is closed by layers and a non-padded cast is applied from the toes to the knee.

The cast is removed in from two to three weeks, at which time the sutures are removed and the wound inspected. Another cast is applied and allowed to remain for six weeks. At the end of this period the condition of the fracture clinically and by roentgenograms is used as a guide for future treatment.

It is believed that more training in orthopaedic surgery is required for closed reduction, than for the open method which should present no obstacles to the general surgeon. It is an extremely difficult manipulation to reduce a spiral, oblique fracture, and to hold such a fracture in position is often impossible.

One of the frequently mentioned disadvantages of an open reduction is that it converts a simple fracture into a compound fracture, with increased susceptibility to infection. In none of these cases has such an infection developed, or, indeed, any type of infection. As may be seen in Table II, the postoperative reaction, as revealed by the pulse and temperature, has been minimal. It has been less severe than that shown by the average hernioplasty. It may be pointed out here, however, that the greatest attention is paid to asepsis, including the smallest details.

Table III shows averages computed from Tables I and II. It is seen

TABLE IV

COST OF OPEN AND CLOSED METHODS OF TREATMENT

Method of Treatment	Cost to Patient by Reason of Time Lost from Work *	Cost to Hospital †	Total Cost Involved ‡
Closed	$388 96	$320 89	$709 85
Open	274 56	128 44	402 90
Difference . .	$114 40	$192 45	$306 95

* Estimated on the basis of a thirty-day month at $57.20 per month. This is the figure used by the Works Progress Administration as the basic pay for common labor.

† Estimated at $3.75 per bed *per diem*.

‡ Out-patient cost at the standard figure of $1.50 per treatment has not been included in this cost. If it were, it would increase the cost for the closed method.

that patients with fractures treated by open methods were ambulant without support in two and nine-tenths months, while those treated by closed methods needed support of some type, usually a cast, for five and seven-tenths months. The patients treated by closed methods also lost more time from work, six and eight-tenths months, as compared with four and eight-tenths months, or a difference of two months.

The reason for the increase in hospital days for patients with fractures treated by closed methods over those treated by open methods is not known. Apparently the attending physician felt that it was not safe to allow the former to begin out-patient status, wearing a cast, as soon as those who had been treated by the open method, and it is a fact that a fibrous type of union, as well as bony union, occurs much earlier in the fractures which have been given open treatment.

The average number of days spent under treatment, that is, hospital days plus out-patient days, is sixty-two days, or two months, more for patients receiving the closed treatments than for those given the open treatments.

Perhaps some explanation should be given of the total lack of poor results and complications in the case of the fractures given open treatment. While it is true that only good results were encountered in this small series, this does not necessarily mean that there never would be poor results. On the contrary, in a larger series poor results would probably occur in some cases. However, even though the number of cases is small, the difference in the two series is striking enough to justify the conclusion that the percentage of poor results would be higher in the patients not operated upon. This is confirmed by operative findings, which often show a fracture which, because of interposed soft tissue, could not be properly reduced by closed methods.

It has been suggested that it would be well to try closed methods first, and, if union was delayed beyond a reasonable time, or if it appeared

that malunion would occur, then open methods. It is believed that, in view of the calm postoperative course, the ease of the procedure, the shorter time that it is necessary for the patient to wear the cast, and the better ultimate results, the procedure of choice in a fresh fracture is immediate reduction and fixation by the open method.

There was one compound fracture in this series. It was treated in the same manner, with gratifying results. If proper cleansing of the wound, together with the necessary débridement is done, it is believed that there is no contra-indication to the immediate reduction and internal fixation of these fractures, if they are seen within twelve hours of injury.

Table IV is interesting in that it approaches the problem from a different point of view. The cost of fractures treated by the open and closed method is analyzed. The figures are only a rough approximation, but they serve to make an interesting comparison. The table shows that a saving of $306.95 per patient is made by using immediate open reduction and fixation of these fractures. This is more than enough to pay for the treatment of two more similar cases.

SUMMARY AND CONCLUSIONS

From an analysis of the results obtained by the open and closed methods of treatment in fifteen cases of spiral, oblique fracture of both bones of the leg, immediate open reduction with internal fixation appears to be the procedure of choice.

A REVIEW OF TWO HUNDRED AND ONE CASES OF SUPPURATIVE ARTHRITIS *

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This paper deals with the method used, the results obtained, and the details of treatment in 201 patients with acute suppurative arthritis, from the Orthopaedic Department of the Allegheny General Hospital, Pittsburgh. This group includes those cases treated since 1921, at which time this method was first used at the Hospital, and the cases are from the Services of David Silver, M.D., Paul B. Steele, M.D., Carl C. Yount, M.D., and the author.

Willems [1] in 1919 discussed the use of incision and active motion in joints affected by penetrating wounds and intra-articular fractures resulting from war injuries. He also considered the advisability of the use of this method in purulent arthritis, and described the results obtained in a few cases involving the knee and elbow joints.

Two hundred and one patients, comprising a total of 221 joints, have been treated since 1921, including all of the joints of the extremities. In each case the presence of actual suppuration either was demonstrated by aspiration and culture, or the author was reasonably certain from other clinical and laboratory findings that it was present, before incision was performed. Joints which were felt to be the seat of serous or serofibrinous infection were treated by more conservative methods, and are not included in this series.

The surgical procedure carried out involves briefly the incision of the joint, under general anaesthesia, and the suturing of the appropriate-sized, soft-rubber drain to the capsule. This drain is never allowed to intrude into the joint. Active motion is started as soon as possible after the effect of anaesthesia is over, and is repeated every three hours. The joint is put through its full range of motion in so far as it is possible, and it will be found that after a few times the limb can be moved freely and without pain. Only in infants and very young children has it been necessary to depend upon passive motion. During the first few treatments a great deal of time and patience must be used to overcome the child's fear of pain, but once he finds that the procedure is practically painless, no further difficulty is encountered. It is occasionally necessary to replace extruded drains and reopen pockets, but most of this can be done without anaesthesia.

Early weight-bearing and walking was tried in a few cases but, in the author's experience, this does not hasten recovery. Ordinary adhesive traction with only a small amount of weight is used for patients with hip or knee-joint involvement. In younger children, in whom the

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, New Orleans, Louisiana, January 14, 1941.

TABLE I

INCIDENCE OF SUPPURATIVE ARTHRITIS

	Knee	Hip	Ankle	Wrist	Elbow	Shoulder	Small Joints	Multiple	Total
Number of Patients	72	65	17	10	8	7	4	18*	201
Number of Joints...	85	74	20	10	14	13	5		221
Patients with complicating osteomyelitis	10	6	5		1	2			24

* Eighteen multiple cases involving thirty-nine joints, one patient having four joints involved.

hip joint has been opened, the limb should be kept in abduction to prevent subluxation.

In the shoulder joint the anterior incision through the deltoid fibers has been used; in the elbow one incision posteriorly over the radiohumeral region usually suffices; and in the wrist, the dorsal incision into the anatomical snuffbox. The approach to the hip joint used most commonly has been an anterior one between the sartorius and the tensor fasciae femoris. In a few instances the posterior incision has been used, but it is felt that the anterior one is more satisfactory, particularly since it is not necessary to use dependent drainage with active motion. The knee joint is opened by a mesial anterior incision with occasionally a second one on the lateral side of the patella; and the ankle joint, by posterolateral and anteromesial incisions. After the joint is opened, it is gently flexed and extended a few times to express the contents before the drain is sutured in place.

The wound is dressed with "fluffed" gauze, piled on very loosely, and secured above and below by bandage or adhesive in such a fashion

TABLE II

TYPE OF INFECTION IN CULTURES MADE

	Knee	Hip	Ankle	Wrist	Elbow	Shoulder	Small Joints	Total
Staphylococcus aureus.....	18	22	3	2	3	1	1	50
Hemolytic streptococcus....	19	11	3		2	2		37
Negative joint culture....	9	1	6		3			19
Gonococcus	8	1		4	1			14
Staphylococcus albus. ..	3	3	2	1		1		10
Streptococcus viridans. ..	1	5	1				1	8
Pneumococcus.		2						2
Total................	58	45	15	7	9	4	2	140

TABLE III

AGE OF PATIENTS AND JOINTS INVOLVED *

Age †	Knee	Hip	Ankle	Wrist	Elbow	Shoulder	Small Joints	Total
Birth to one year	3	8						11
One year to ten years	13	22	6		6	4	1	52
Ten to twenty years	24	20	7	3	2	5	1	62
Twenty to thirty years	19	8	4	4	3		1	39
Thirty to forty years	11	11	2		1			25
Forty years and over	15	5	1	3	2	4	2	32
Total	85	74	20	10	14	13	5	221

* Eighteen patients are listed more than once because of multiple-joint involvement.
† Age of youngest patient was twelve days, and age of oldest patient, seventy-three years.

as to allow complete joint motion. Drains are removed and the opening is allowed to close gradually when the discharge becomes thin and scanty, and the thickening and bogginess about the joint begin to disappear.

Thirteen deaths were directly attributable to the joint infection. Of these, eight had a staphylococcus aureus blood culture, three a hemolytic streptococcus blood culture, and two a negative blood culture. Six deaths were in patients with nephritic, diabetic, and cardiac complications. These conditions were known to have been present before the joints were affected.

In this series of cases there were twenty-four patients with complicating osteomyelitis of adjacent bones of such severity that drainage or sequestrectomy was necessary (Table IV). It was possible to continue the active joint motion with all these patients, and the results obtained were not at too great variance with those in uncomplicated cases.

As criteria of so-called successful results in our tabulation, the following range of motion was accepted.

TABLE IV

RESULTS IN TWENTY * PATIENTS WITH OSTEOMYELITIC COMPLICATIONS

Results	Knee	Hip	Ankle	Wrist	Elbow	Shoulder	Small Joints	Total
Deaths		4			1			5
Followed	5	4	3		1	2		15
Stiff		1	1					2
Not satisfactory	1	2	1					4
Satisfactory	4	1	1		1	2		9

* There were twenty-four patients in this group, but four were not followed. Sixty per cent. of the patients who lived had satisfactory results.

TABLE V

RESULTS IN ELEVEN * PATIENTS WITH GONORRHEAL INFECTION OF THE JOINTS

Results	Knee	Hip	Ankle	Wrist	Elbow	Shoulder	Small Joints	Total
Deaths				1				1
Followed	6			3	1			10
Stiff	1				1			2
Not satisfactory	1			1				2
Satisfactory	4			2				6

* There were fourteen patients in this group, but three were not followed. Sixty per cent. of the patients who lived had satisfactory results.

Hip: No subluxation, flexion to 75 degrees, complete extension, and abduction to 15 degrees.

Knee: Complete extension, and flexion to 75 degrees.

Ankle: Plantar and dorsal flexion to from 20 to 25 degrees.

Shoulder: Elevation to 90 degrees, forward flexion and adduction to from 10 to 15 degrees.

Elbow: Flexion to 90 degrees, and extension to 165 degrees.

Wrist: Dorsal flexion to from 20 to 25 degrees, and palmar flexion to from 30 to 35 degrees.

In the follow-up tabulation of patients not examined recently, the statement that the joint was "movable and not stiff" at this time, was accepted as a successful result provided the joint had also been satisfactorily movable at the time of the patient's discharge from the hospital.

TABLE VI

ANALYSIS OF RESULTS FOR 112 JOINTS IN 93 PATIENTS

Results	Knee	Hip	Ankle	Wrist	Elbow	Shoulder	Small Joints	Total
Deaths (19 patients)	4	11	2	1	1			19
Joints followed (93 patients)	34	33	12	3	4	4	3	93
Joints examined	24	25	7	3	3	3	1	66
Follow-up cards	10	8	5		1	1	2	27
Stiff	2	5	3		1			11
Not satisfactory	4	9	2	1		1		17
Satisfactory	28	19	7	2	3	3	3	65
Percentage of satisfactory results in patients who lived	82	58	58	67	75	75	100	70

In checking over this series it appears that there have been more unsuccessful results in patients with hip-joint involvement, particularly in younger children, than in any of the others. It is felt that this is because of:

1. Late institution of treatment, after the purulent material has ruptured through the capsule and the head has been floated outward and upward.

2. The difficulty of early diagnosis.

3. Failure to maintain the limb in abduction and extension following incision, for a sufficient length of time.

Other reasons for bad results are:

Poor cooperation between the patient and the attendant when active motion is first begun, following operation. The surgeon, himself, must at least supervise, and in most cases carry out, the treatment until routine motion is established. This phase of treatment must not be delegated to those unfamiliar with the technique.

Insufficient drainage. In some cases two incisions at the knee or the ankle might have been better than one.

Too early removal or extrusion of the drain, and drains which may have been placed within the joint by mistake.

Operative intervention in a few patients who may have been too ill. Aspiration, washing out of the joint, or other conservative measures should possibly have been tried.

In the last few years an attempt has been made to reconcile the more radical ideas of the treatment of these purulent joints with those used in the treatment of acute osteomyelitis.

CONCLUSIONS

1. In the author's experience the Willems method of treatment of acute suppurative arthritis gives entirely satisfactory results when instituted at, or very soon after, onset.

2. Results become progressively less satisfactory in proportion to the length of time after onset at which treatment is started. This is believed to be the result of several factors:

(a) When sufficient time has elapsed for adhesions to develop, the pockets thus formed cannot be drained properly by the active movements. Indeed, it is possible, that this may be actually harmful in promoting absorption from such pockets.

(b) In cases of long standing, erosion of cartilage with denuded bone areas hinder or prevent efficient active movements.

(c) In cases of long duration, blood-stream infection is an ever-present danger, as well as an aggravation of existing organic diseases by the infectious process.

With these older cases some more radical procedure is obviously necessary.

1. WILLEMS, C.: Treatment of Purulent Arthritis by Wide Arthrotomy Followed by Immediate Active Immobilization. Surg. Gynec. Obstet., XXVIII, 546, 1919.

PRIMARY PYOGENIC INFECTION OF THE SACRO-ILIAC ARTICULATION. A NEW APPROACH TO THE JOINT

Report of Seven Cases

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That pyogenic infection of the sacro-iliac joint is an unusual condition is indicated by the fact that L'Episcopo's report of five cases is the only article the author found in the literature under this title.*

He has recently seen seven cases of primary suppurative arthritis of the sacro-iliac articulation, and in three of them has used a new approach for the drainage of this joint when abscess formation had taken place anteriorly.

TECHNIQUE OF ANTEROLATERAL APPROACH TO THE SACRO-ILIAC JOINT

With the patient in the supine position, an incision four or five inches long is made one-half inch above, and parallel to, the crest of the ilium, starting over the anterior superior iliac spine (Fig. 1). The inferior edge of the wound is dissected down, and the attachments of the abdominal muscles to the crest are cut over the superior border of the ilium, but not on its outer aspect. This is done in order to leave the skin flap and underlying structures attached to the crest of the ilium, thus preventing the retraction of the lower edge of the incision. After cutting the aponeurotic attachments of the abdominal muscles, the periosteum is incised at the same level; then, with a periosteal elevator, the iliacus muscle is stripped subperiosteally, following the anterior aspect of the ilium in a medial and slightly downward direction. This muscle is retracted medially, and from then on the periosteal stripping is carried out by the gloved finger. Going deep enough, the lateral attachments of the anterior ligaments of the joint are found; these are cut, or detached with the periosteal elevator. The joint can then be explored in all its length. By extending the incision further back, with good retraction, the articular surfaces of the ilium and sacrum can easily be exposed. The wound is left open and packed with vaseline gauze. Healing is assisted by intra-abdominal pressure, and, as it takes place and drainage diminishes, the vaseline gauze packing is gradually pushed out.

DISCUSSION

In the seven cases reported (Table I), staphylococcus infection of the joint was proved in three, streptococcus was responsible in one, and the organisms in the other three are unknown. In six cases the abscess for-

*The articles by O. C. Hudson were not known to the author until after the present article had been written.

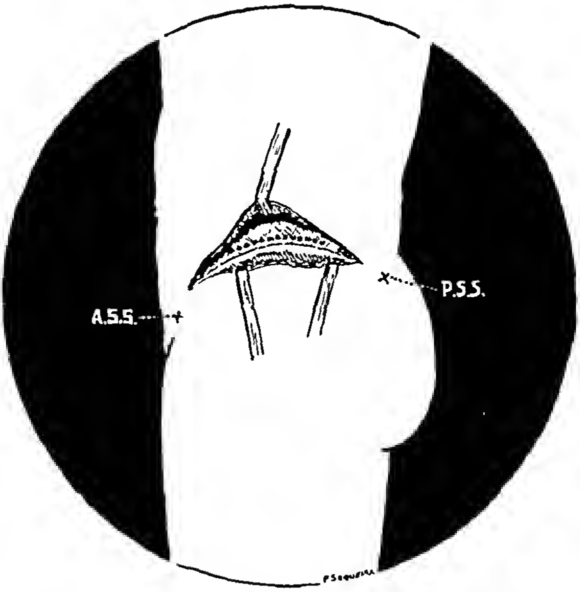

Fig. 1

Drawing of the incision above the iliac crest. Dotted line shows the location of the incision of the aponeurosis on the superior aspect of the iliac crest. The inferior edge of the wound has been retracted down for illustrative purposes.

A.S.S. = anterosuperior spine; P.S.S. = posterosuperior spine.

mation took place anteriorly, and, although the iliac fossa of the affected side was painful in all, a real indication that the abscess was forming anteriorly, as a hard tumor on the iliac fossa, did not appear until the fifteenth or twentieth day after the onset of symptoms. This tumor, on exploration, proved to be the iliacus muscle which reacted to the infection in the form of an inflammatory myositis, such as is sometimes seen in the presence of osteomyelitis elsewhere. This tumor was not the abscess which was located deep in the iliac fossa, and this fact should be stressed, because it would be possible to cut into the muscle and not reach the deeper abscess.

Only two cases will be described in detail, as the clinical picture has been practically the same in all.

Case 1. S. E., male, aged nineteen, was well until February 27, 1940, when he felt pain in the left side of the back, which radiated down the left leg. On admission to the hospital, February 29, 1940, he was suffering such severe pain that the slightest movement was intolerable. His temperature was 39 degrees centigrade, and the blood count was: red blood cells, 3,500,000; white blood cells, 15,000. After one and eight-tenths grams of sulfanilamide had been given daily for six days, the temperature became normal, but the pain persisted unabated.

This patient was referred to the writer on March 30, 1940.

Physical Examination: There was exquisite tenderness to pressure over the left sacro-iliac region. The lumbar spine was obviously flattened, and there was marked muscle spasm in the lumbar region. There was pain along the sciatic nerve, but no objective neurological signs were elicited. The straight-leg-raising sign was positive on the left side. The abdomen was soft and painless, but on *the left side a mass* could be seen filling the iliac fossa to the anterior superior iliac spine, and all *along the fossa a hard elongated mass was felt.* Pain was only elicited on deep pressure over this area.

Roentgenograms taken March 28, 1940, showed a destructive lesion of the left sacro-iliac joint (Fig. 2-A).

Operation: Arthrotomy was performed on April 5, 1940, through the anterior approach already described.

A small amount of pus was found, and the wound was left wide open. An incision was made into the hard, fibrotic mass which was found to be the iliacus muscle. Two days after the operation, the patient began to feel relief from the pain which disappeared

completely a week afterwards. This patient was operated upon again through the same incision because of insufficient drainage; he made a complete recovery (Fig. 2-B).

On culture of the pus, the offending organism was found to be staphylococcus albus

Fig. 2-A

Case 1. S. E. Roentgenogram taken March 28, 1940, eight days before operation, shows well the sacro-iliac joints. Note the destruction on the left; the right one is clearly seen.

Fig. 2-B

Case 1. S. E. Roentgenogram taken October 5, 1940, six months after operation, shows that the left sacro-iliac joint has started to fuse.

FIG 3-A

Case 5. C. O. Roentgenogram taken August 9, 1940, before operation, shows some destruction of the right sacro-iliac joint

FIG. 3-B

Case 5 C O. Roentgenogram taken December 18, 1940, three months after operation, shows trabeculation and ankylosis on the right side

CASE 5. C. O., a nine-year-old girl, was hospitalized on July 27, 1940, because of high temperature, inability to walk, and pain on the right side of the lower back. There was an adduction, internal rotation, and flexion deformity of the right lower limb, and *a painful tumor in the right iliac fossa* (Fig. 3-A). A diagnosis of psoitis was made, and an abscess was drained through an incision one inch above the right inguinal ligament. Due to the persistence of her symptoms, she was transferred to the Orthopaedic Service on September 8, 1940.

The tumor of the iliac fossa was still present, in spite of a draining sinus from the first operation, and there was tenderness over the sacro-iliac region on the right side, which at this time was obviously swollen and warm.

Roentgenograms taken at that time showed some increase in density of the surrounding bone of the right sacro-iliac joint.

Primary acute sacro-iliac arthritis was diagnosed, and the patient was operated upon by the anterolateral approach, disregarding the previous abdominal incision.

On culture the offending organism was found to be staphylococcus.

Operative Findings: The right sacro-iliac joint was explored in all its length. The anterior edge of the articular surface of the sacrum was sharp, and it formed a step of about one-eighth of an inch. Abnormal motion was induced by applying force on the ilium in different directions.

Postoperative Course: Two days after the operation the pain had decreased and at the end of a week had disappeared completely; the temperature became normal; the patient was allowed up at the end of a month. She had a limp, due to the deformity of the right lower limb, but no pain. By December 10, 1940, the limp had disappeared, the wound had healed, and she was able to run and jump with no trouble whatsoever. The primary wound had healed soon after good drainage had been provided by the second operation.

All cases reported in Table I were primarily of an acute suppurative arthritis. In each case roentgenograms showed only a destructive lesion of the joint. These patients were all followed for five months after discharge from the hospital, and remained well,—none complaining of pain in the back. Roentgenograms taken one and two months after the operation showed no increase in the destruction of the articulation; on the contrary, trabeculae had started to form between the sacrum and the ilium, indicating the beginning of ankylosis.

Of these patients only four required operation. Three of the operations were performed through the anterior approach, and one through the Smith-Petersen incision for the sacro-iliac joint. The three patients who were not operated upon showed all the characteristic signs of suppurative sacro-iliac arthritis, including roentgenographic, but the virulence of the pathogenic agents was probably mild, and the patients recovered under conservative treatment. Pain was the principal symptom to be considered, as temperature was controlled by the use of sulfanilamide and stock vaccines in all but two cases (Cases 3 and 5).

Two of the patients were women in whom the disease developed within three days after delivery.

SUMMARY AND CONCLUSIONS

Of seven cases of primary pyogenic infection of the sacro-iliac joint, three were due to staphylococci, one to streptococci, and the cause of three was not known. All seven patients made a complete recovery.

TABLE I

Résumé of Seven Cases of Suppurative Arthritis

Case No	Sex and Age	Chief Complaint	Tumor of the Iliac Fossa	Posterior Swelling	Flexion Adduction Internal Rotation Deformity	Sciatic Pain	Fever Controlled	Operation Performed		Conservative Treatment	Results
								Anterior Approach	Posterior Approach		
1	Male 19	Pain in back	Yes	No	No	Yes	Yes	Yes			Cured
2	Male 19	Pain in back	Yes	No	No	Yes	Yes	Yes			Cured
3	Female 30	Pain in back	No	Yes	Yes	Yes	No		Yes		Cured
4	Female 17	Pain in back	Yes (very small)	No	No	Yes	Yes			Yes	Cured
5	Female 9	Pain in back, inability to walk	Yes	Yes	Yes	Yes	No	Yes			Cured
6	Male 37	Pain in back, limp	Yes	No	Yes	Yes	Yes			Yes	Cured
7	Male 9	Pain in back, fever	Yes	No	Yes	Yes	Yes			Yes	Cured
Total		7	6	2	4	7	5	3	1	3	7

Due to the peculiar anatomy of the joint, a posterior approach will not drain an anterior abscess, and *vice versa*. In this small series of seven cases, the abscess formed anteriorly in six patients.

The author has found a new anterior approaeh valuable.

The author is indebted to Don E. King, M.D., of Stanford University Hospital, San Francisco, California, for the correction and sound criticism of this article.

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INTERINNOMINO-ABDOMINAL (HIND-QUARTER) AMPUTATION

BY SETH SELIG, M.D., F.A.C.S., NEW YORK, N. Y.

Billroth, in 1891, performed the earliest recorded interinnomino-abdominal amputation, but the patient survived only a few hours. Since then, a considerable number of successful cases have been reported in the English, French, German, and Russian literature. Gordon-Taylor, a British surgeon, reported the amazing total of eleven cases with four deaths. However, only two successful cases (surviving a week or longer) have been reported from this country.

CASE REPORT

J. J., a male Puerto Rican, aged twenty, was admitted on January 24, 1940, to the author's Service at the Mount Sinai Hospital, because of pain and swelling of the left hip region of three weeks' duration. General physical examination was negative except for a few small shotty lymph nodes in both inguinal regions, limitation of motion of the left hip joint in all directions, and a tender, semifluctuant mass about the size of an orange over the greater trochanter. The temperature ranged between 100 and 104 degrees, and any movement of the hip caused agonizing pain. Aspiration of the mass was unsuccessful. The tuberculin test and the Wassermann test were negative, and the urine showed no pathologically formed or chemical elements. The blood count revealed a hemoglobin of 87 per cent. with a red-cell count of over 5,000,000. The sedimentation rate was rapid. Roentgenographic examination of the hip, the pelvis, and the lungs failed to reveal any abnormalities.

On February 7, an incision was made over the greater trochanter and a large amount of gray, necrotic, semifluid tissue was obtained. In addition, specimens were removed from the wall of the cavity. Because no roentgenographic evidence of bone involvement was noted, the pathologist reached the conclusion that the tumor was a round-cell sarcoma, possibly of synovial origin (Fig. 1). The roentgenotherapist was then called in consultation, and after examining the patient and the specimen, he stated that synovial sarcomata were not radiosensitive, and that even if roentgenotherapy were desired, it should be delayed until the wound had healed. At that time, the wound was gaping and the neoplasm had begun to protrude from the wound. The condition of the patient was pitiable. Because of the desperate situation, and because roentgenograms of his lungs and bone structure failed to reveal any evidence of metastases, it was felt that the patient should be subjected to a hind-quarter amputation.

On February 23, 1940, spinal anaesthesia was administered, using 120 milligrams of neocaine. In spite of the fact that the spinal anaesthesia was smoothly given, it was not effective, and it was necessary to use supplementary gas-oxygen-ether anaesthesia. An intravenous drip of saline was started before the incision was made, and blood was available for a continuous transfusion during the operation. The patient was placed in the supine position, but the left lower extremity was draped in such a fashion that he could be turned onto his right side without disturbing the drapes. The surface of the biopsy wound, which was obviously infected and through which the neoplasm was beginning to bulge, was thoroughly cauterized with the actual cautery. The author had the able assistance of Dr. R. Colp during the entire procedure, particularly in dealing with the structures about the inguinal ring and Poupart's ligament.

The incision followed closely the description given by Pringle, which in turn resembled the incision of Girard except that no mesial flap was planned. The incision began at the mesial aspect of the thigh about one inch distal to the crural-scrotal fold,

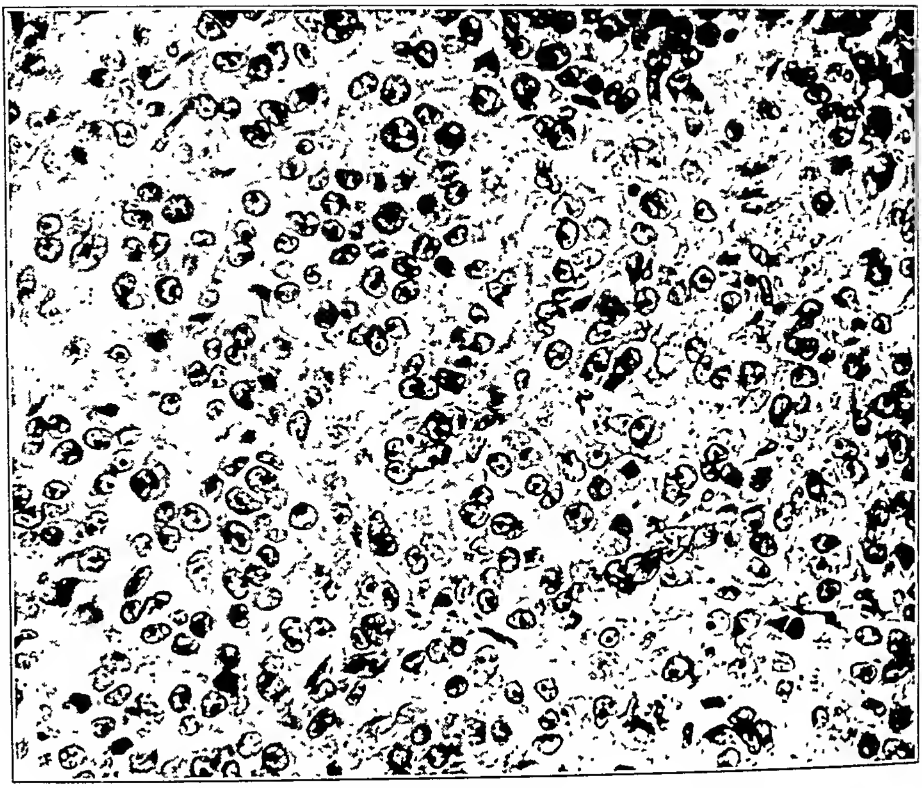

Fig. 1

High-power photomicrograph of the neoplasm (endothelial myeloma).

and continued anteriorly about one inch below Poupart's ligament, gradually approaching Poupart's ligament until the incision reached the anterior superior spine of the ilium. Poupart's ligament was cut laterally where it takes origin from the ilium, and both it and Gimbernat's ligament were severed mesially, and the spermatic cord was retracted mesially. The rectus abdominis muscle was cut close to the pubic bone, and the transversalis fascia enclosing the abdominal contents was pushed upward. During these steps the superficial and inferior epigastric vessels and the circumflex iliac vessels were severed, readily clamped, and ligated. The upward displacement of the abdominal contents proved surprisingly easy because the proper plane had been reached. The ureter remained with the peritoneum and was not seen during the operation. After isolating the external iliac artery, the external iliac vein, and the femoral nerve, they were doubly ligated with heavy silk, and cut across. During the operation, the three large nerve trunks which were severed, were all ligated before section. This was done to prevent bleeding from the arteries that course with or along the nerve trunk. In the case of the sciatic nerve, alcohol was injected before section. The transversalis fascia with the abdominal contents could now be pushed further upward, exposing the lateral wall of the pelvis. At this point the obturator artery and nerve could be seen along the lateral wall of the pelvis in their course to the obturator foramen. The vessel and nerve were doubly ligated, and cut. The bladder, with its surrounding fat, was pushed toward the right side, away from the symphysis pubis, and the cartilaginous symphysis was easily cut through with a scalpel. During this procedure, the bladder was protected by the author's hand.

The patient was then turned on his right side, and the incision was continued along the iliac crest, to the posterior superior spine of the ilium, and from the posterior superior spine of the ilium to the gluteal fold, and along the gluteal fold to the perineum where it met the beginning of the incision which had been made when the patient was

supine. On cutting through the gluteus maximus, the uppermost portion of the neoplasm was incised. The instruments were changed, and the incision was made at a higher level to completely circumscribe the tumor. The incision was carried to the bone through the gluteus maximus, and then carried along the posterior margin of the ilium. The superior gluteal artery was carefully watched for, doubly ligated, and cut. This is a large vessel which can cause a fatal hemorrhage if it is cut and permitted to retract into the pelvis. Anterior to the gluteus maximus, the sciatic nerve and inferior gluteal (sciatic) artery were exposed, doubly ligated, and cut, after the nerve had been injected with one cubic centimeter of absolute alcohol. The internal pudic artery was exposed, tied, and cut where it crossed over the spine of the ischium after leaving the pelvis. The sacrospinous and sacrotuberous ligaments were cut with slight bleeding. The coccygeus and levator ani muscles were cut, and the soft parts were then stripped from the rami of the pubis and ischium, care being taken to keep close to the bone. No bleeding at all was encountered during this last step, because the internal pudic artery had been tied. Commencing near the posterior superior spine of the ilium and sawing downward into the great sacrosciatic notch, the iliac bone was then sawed through, close to the sacrum. This is much simpler than attempting to disarticulate the sacro-iliac joint. The pelvis was then connected to the body only by the psoas muscle which, after ligation, was cut through just above the pelvic brim.

FIG. 2

Coronal section through the hip joint, showing the relationships of the neoplasm to the surrounding structures.

The wound was closed by heavy tension mattress sutures of silk. No attempt was made to close the wound layer by layer, as the patient's condition was giving concern at that time, and speed was necessary. Two rubber-dam drains and two packings were inserted at the upper and lower angles of the wound, and a compression gauze dressing was applied. The total operating time was ninety-five minutes.

Attention should be called to the fact that the internal iliac artery was not tied, but merely the important branches as they came into view. It has been noted that if both the internal and external iliac arteries are ligated, there may be necrosis of the flaps. With this procedure, there was surprisingly little bleeding. A continuous intra-

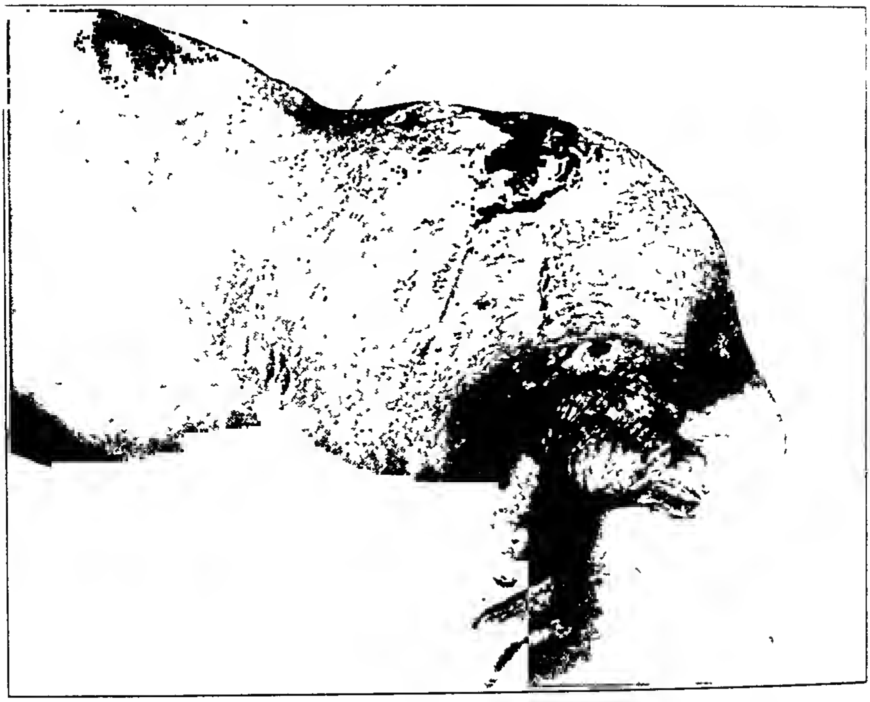

Fig. 3

Postoperative photograph of the patient, showing the healed anterior part of the wound, and the large granulating posterior portion.

venous infusion of citrated blood was given, and during the operation and immediately afterward the patient received 1200 cubic centimeters of blood.

After the operation had been finished and the anaesthesia was stopped, the patient rapidly regained consciousness, but it was deemed unwise to remove him from the operating table immediately, and he was left on the table in the Trendelenburg position. At 11:45 in the morning—that is one hour and a half after the conclusion of the operation—the patient's blood pressure was about 106, and his condition appeared satisfactory. A bed was then moved into the operating room, and the patient was carefully lifted from the operating table into the bed. Immediately, his condition underwent a dramatic change. He became exceedingly pale, his pulse became imperceptible, and his blood pressure fell to fifty-five systolic. He was given an additional 300 cubic centimeters of blood, and the foot of the bed was raised to combat the shock. He was given ten milligrams of desoxycorticosterone intramuscularly, and six minims of adrenalin intravenously. Within a few minutes, his systolic blood pressure rose to 170, but quickly fell to 128, at approximately which point it remained for the rest of the day. The bed was wheeled to the ward with the foot elevated, so that at no time was the Trendelenburg position lost. From that point on, the patient's condition rapidly improved, and he voided spontaneously the night of the operation.

The specimen proved most interesting. The growth had perforated through the iliac bone into the pelvis and lifted up the iliacus muscle. At one point the fibers and the muscles were pushed apart by the growth. The deep inguinal nodes were enlarged to the size of a plum. On section they were soft and yellowish gray in color. The superficial inguinal nodes were only moderately enlarged, and had a similar appearance on section. The gluteal muscles were also lifted up by that portion of the tumor which arose from the lateral aspect of the ilium. Upon coronal section (Fig. 2) through the ilium, hip joint, and femur, the relationship of the tumor to the surrounding structures could be noted. The tumor measured fifteen centimeters in its longest diameter.

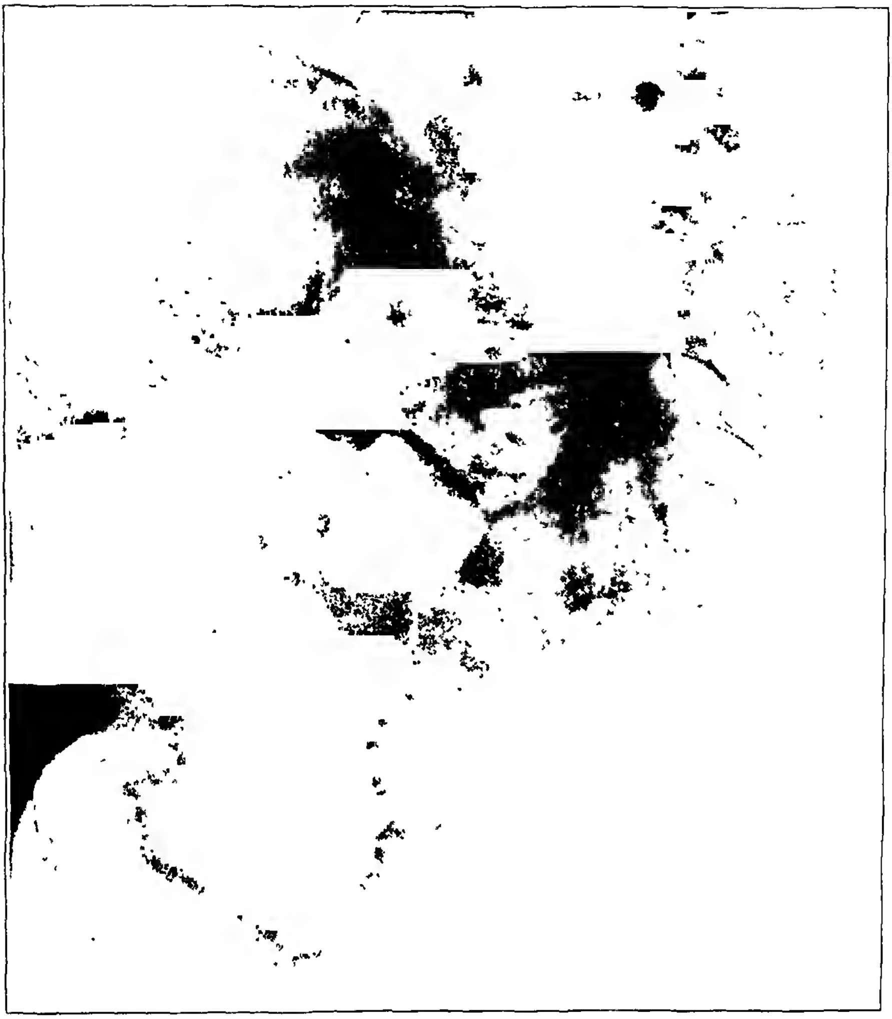

FIG. 4

Postoperative roentgenogram of the patient, showing the small segment of ilium, remaining after amputation.

The tumor was also firmly fixed to the external and uppermost aspect of the capsule of the hip joint. The pathological diagnosis of the resected specimen (Fig. 1) was an endothelial myeloma (Ewing's tumor). This diagnosis was not made from the original biopsy specimen, because no bone origin or involvement of this huge growth was discernible on the roentgenograms. Had the author been aware of the true diagnosis before operation, he would have advised roentgenotherapy, rather than the radical operation.

In a few days after the operation the patient's morale rose, because he had been relieved of the severe pain. He developed a mild infection in the wound, which responded to sulfanilamide. There was some gaping of the skin and sloughing of the fascia, but the deeper structures healed well (Figs. 3 and 4). There was no evidence of herniation through the wound. (Keen mentions the theoretical danger of hernia, but the strong transversalis fascia is sufficient to prevent herniation of the abdominal contents.) Healthy granulation tissue appeared in the wound, and epithelization of the edges progressed rapidly. Some difficulty in spontaneous bowel movements was encountered, and daily enemas were necessary.

After several weeks, a change was noted in the patient's condition. He lost weight and strength, his appetite decreased, and a gradual recurrence of pain was noted. His subsequent course was rapidly downhill, and multiple metastases developed to the lungs, pleura, and liver, as well as lymph nodes, and a local recurrence at the operative site. Roentgenotherapy failed to halt the progress of the neoplasm.

The patient died forty-five days after the operation, and autopsy revealed the multiple metastases noted above.

The extreme rapidity in development of the metastases where none had previously been noted by careful roentgenographic examination makes one wonder whether the operation itself may have hastened their development.

The operation is a multilating one, and it is attended by a high mortality, but it should be attempted in cases presenting a radioresistant neoplasm about the hip joint, too high for disarticulation. Of course, a careful preoperative examination must be made by clinical and roentgenographic means to rule out the presence of metastases.

The operation has also been advised for uncontrollable chronic infections about the hip joint and dissecting aneurysms of the femoral artery.

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CARPAL BOSS: A COMMONLY OVERLOOKED DEFORMITY OF THE CARPUS *

BY RALPH M. CARTER, M.D., GREEN BAY, WISCONSIN

About five years ago, there came under the author's observation a patient presenting an unusual deformity of the wrist. The history follows:

CASE 1. The patient, a single woman, thirty years of age, was a trained nurse by occupation. Several months previous to examination, she had noticed on the posterior aspect of her right wrist a small, hard growth, apparently of bone, which had gradually been increasing in size. So far as she knew, there had been no antecedent injury. She complained of only two symptoms: The hand tired rather more easily than normally, and there was an occasional sensation as though an extensor tendon had caught over the tumor, and immediately slipped off with a definite jerk.

The general physical examination was negative. Upon inspection of the wrist, there was to be seen, upon the posterior aspect, a definite rounded tumor. This tumor, situated at the base of the third metacarpal bone, was firm in consistency, was painless upon pressure, and was apparently firmly attached to the underlying bone. The skin was freely movable above it. The tumor was approximately one centimeter in diameter, and was much more apparent with the hand in extreme palmar flexion (Fig. 1-A).

A lateral roentgenogram showed that the tumor was a definite outgrowth of bone posteriorly from the distal articular surface of the os capitatum of the wrist, and a similar outgrowth from the proximal articular surface of the third metacarpal; in other words, there seemed to be a fully developed posterior "lipping" of the articular surfaces of both bones, with complete preservation of the articulation itself (Fig. 1-B).

At that time the author was unfamiliar with the condition as a clinical entity, and he considered it an unusual osteo-arthritic manifestation, similar to the spur formation which is not infrequently seen at the metatarsophalangeal joint of the great toe. In view of the fact that the interference with tendon function was annoying, the patient desired treatment, and removal of the bone spurs was suggested. At operation, the condi-

FIG. 1-A

External appearance of deformity with wrist in palmar flexion.

* Presented before the Chicago Orthopaedic Society, Chicago, Illinois, February 14, 1941.

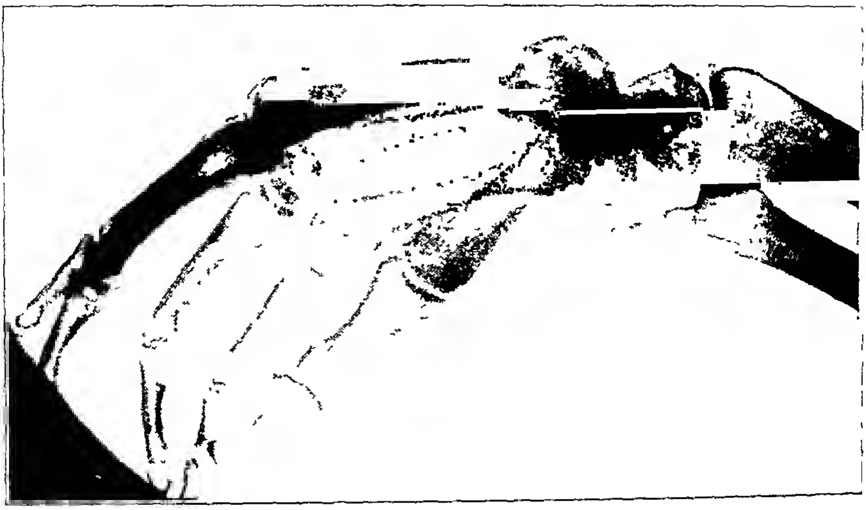

FIG. 1-B

Roentgenogram showing bone bosses at articulation of the third metacarpal and the capitate bone of the wrist.

tion was found to be as was shown in the roentgenograms. The spurs were removed, and the symptoms disappeared. Within a few months, the tumor had reappeared, and the roentgenogram revealed that the preoperative condition had recurred. However, there has been no recurrence of symptoms, and the tumor, having again attained its original dimensions, has since shown no tendency to increase in size.

A few months later, a second patient was seen, with a condition similar in every respect to the first one, so far as physical and roentgenographic examinations disclosed.

CASE 2. A male laborer, thirty-five years of age, had a tumor which had gradually developed, following a moderate blow on the posterior aspect of the wrist, two or three months previous to consultation. Symptoms were almost entirely absent, although the patient stated that after a hard day at work, the wrist occasionally ached, and that the wrist and hand seemed to tire more readily than formerly. In view of the experience with the first case, surgical removal of the bone tumor was advised against, because a recurrence appeared to be a likely possibility. The patient, however, was insistent that removal be tried. This was done, but within a comparatively short time, complete recurrence had taken place. This was a compensation case, and it was closed by the payment of a nominal sum for possible permanent disability.

Since then, four additional patients have come under observation. Of these four, one was a stenographer, one was a laborer, and two were housewives.

The stenographer complained of the usual mild symptoms of occasional aching and easy fatigability of the wrist.

In the case of the laborer, the finding was an incidental one in the course of a general physical examination. So far as he knew, the tumor of the wrist had been present for several years, and had given him no trouble of any kind; therefore he had not sought treatment.

One of the housewives presented herself because of a large bursa

FIG. 2

Roentgenogram showing outline of bursa which had developed over the deformity.

which had developed over the bone tumor, the latter being discovered when a roentgenogram of the wrist was made (Fig. 2). Removal of the bursa was suggested, but she did not return for treatment.

The last patient, a housewife, came to examination because of the tumor, associated with the usual mild subjective symptoms. She, likewise, did not return, probably because no assurance of success in treatment could be given.

Investigation of the literature revealed the fact that the condition which has just been described constitutes a definite clinical entity, but one which, so far as the author is able to determine, has been described only in the French medical literature, under the name of "*carpe bossu*", a term which may be literally translated as "bossy wrist" or "carpal boss", using the word "boss" in the sense of a protuberance of bone. No reference to it could be found after a careful search through a number of standard works on orthopaedic surgery and roentgenographic diagnosis, nor could any references to it, other than the articles noted below, be found in the Quarterly Cumulative Index or Quarterly Cumulative Index Medicus from 1920 to the present time.

So far as the author has been able to find, the first case was reported by Fiolle in 1931. Several other articles on the subject followed this first publication, and additional cases were reported by Fiolle and Ailland, Mouchet, Fiolle and Coudray, Chavannaz, Roederer and Charry, Imbert, and Menegaux, the last-named author reporting two cases.

The total number of cases reported in the articles above mentioned is nine; the author's six cases bring the total on record to fifteen. However, the author believes that the condition is much more common than these figures would indicate.

The physical and roentgenographic findings are typical, and are well presented by the cases here shown.

As a rule, symptoms are slight or absent, and the condition, aside from the cosmetic defect, is apparently of little moment. However, as in one or two of the author's cases, and in the two cases reported by Menegaux, mild disability may occasionally be present.

The etiology is unknown, and no cases are reported which would lead to the belief that it may be a congenital condition. Fiolle believes that it may be a syndrome analogous to the lesions of the Mouchet-Köhler type. The opinion has been expressed that the exostoses may be the result of an early fracture. The author is unable to find any evidence, either in the reported cases or in his own, which would lend support to either of these views. Mouchet interprets it as a sequel of a sprain. Tavernier, quoted by Fiolle and Ailland, asks if it may not be an effort deformity, resulting from an occupation requiring repeated pressure from below upwards on the index and middle fingers, thus tending to force the metacarpals on the wrist bones. Menegaux feels that it is entirely possible that the condition may have a traumatic origin. The genesis from trauma is explained as follows: The initial traumatism gives rise to a slight carpometacarpal sprain, with rupture or slight tearing of the dorsal ligament between the capitate bone and the third metacarpal. Then, little by little, a constantly repeated movement of the fingers, by pulling or pressing upon the already slightly traumatized region, will give rise to an ossifying reaction beneath the affected ligament. There will thus be produced the slow formation of the carpal and metacarpal bosses, which will naturally not attract attention until they have become somewhat definitely developed.

Obviously, all of these assigned causes are speculative, and the condition has not been sufficiently studied to prove or disprove any of them. The fact that the deformity always occurs in the same location, and always presents the same roentgenographic appearance, would indicate that some etiological factor is present which is common to all; *a priori*, it would appear extremely likely that this common factor might be an occupational one. However, when the occupations in the reported cases are studied, the question is not answered. Three cases occurred in manual laborers, in one of whom the condition was bilateral; one in a trained nurse, two in stenographers, one in a seamstress, two in housewives, one in a wood carver, and two in surgeons. In three cases, the occupations were not given. Certainly, these occupations would seem to have nothing in common, unless it be the frequently repeated finer movements of the fingers, and this would not apply to manual labor. Furthermore, if such a cause were really active in the production of the condition, the deformity should be found very frequently in typists, in piano players, and in musicians playing other instruments. That the cause which originally produced it in the first case seen by the author probably remained active, is shown by the fact that the exostoses promptly recurred after removal.

A brief report of these cases was presented at a recent orthopaedic meeting *. During the discussion which followed, it was brought out that several of the surgeons present had seen one or two cases; for this reason, it is felt that the condition occurs more frequently than a study of the literature would indicate.

In connection with the question of treatment, one surgeon expressed the opinion that the condition represented an osteo-arthritis of the affected joint, and that removal would be entirely successful and not followed by recurrence if the wrist were immobilized in plaster for a few weeks following operation. Immobilization following operation is an interesting suggestion and worthy of trial. The author did not use it with the two patients upon whom he operated, and it is not mentioned in any of the reported cases. The suggestion that the condition may be an osteo-arthritic manifestation is open to considerable doubt. At operation, these bone bosses do not resemble osteophytes or lipping of the articular margin in any way, but seem to be an actual overgrowth of normal bone in the affected area. No histological studies of the removed bone have been made.

Further, in connection with the operative treatment, Lambert, of Chicago, stated that he had seen one case, also in a trained nurse. The bosses were removed by operation, and promptly recurred; they were removed a second time, and recurrence again took place. The condition at present remains as it was previous to the first operation.

Two considerations prompted the preparation of this report. In the first place, the disease is of interest from an academic standpoint. It is apparently a sharply defined clinical entity, and probably more common than a search of the literature would indicate. Even though it is a comparatively trivial affection, orthopaedic surgeons should have it in mind and be able to recognize it when it presents itself, if only for the purpose of differential diagnosis.

In the second place, and probably of more importance from a practical standpoint, is the fact that disability claims may arise following industrial accidents, as in one of the author's patients. In the published cases, and in his own limited experience, there is nothing to indicate that the condition follows a single trauma of the affected region. On the contrary, it appears to be a gradual development. If a single trauma were the etiological factor, it would seem that the disease would be frequently seen by traumatic surgeons, because contusions of the hands and sprains of the wrist are extremely common, but apparently such is not the case. In the one case seen by the author, in which there was a history of trauma, he is not at all sure that the boss was not present preceding the alleged trauma. Therefore, when such claims are made, the history should be investigated with extreme care.

Apparently these patients should not be operated upon.

* Clinical Orthopaedic Society, Milwaukee, Wisconsin, October 15, 1940.

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HISTOLOGICAL STUDY OF A TRANSCERVICAL FRACTURE OF THE FEMUR AFTER INTERNAL FIXATION

BY ROBERT A. WISE, M.D., NEW YORK, N. Y.

From The Fracture Service of Knickerbocker Hospital, New York

Concentration on methods and appliances for internal fixation of transcervical fractures of the femur has almost completely excluded consideration of the basic histological changes taking place as a result of such fixation. A few pathological reports have appeared in the literature—Palmer in 1934, Jones and Lieberman in 1938, Felsenreich in 1939, Engel in 1940, and Kulowski and Luck in 1941—but, because there are many unexplained factors in the success or failure of this relatively new form of treatment, there is need for continued histological study.

It is the purpose of this paper to report the late microscopic findings in a transcervical fracture of the femur fixed with a vitallium Smith-Petersen nail. The specimen was obtained from the patient thirteen months after operation, when firm bony union, allowing unsupported weight-bearing, had developed. Death was due to carcinoma of the cervix. At no time, either before the fracture occurred or after operation, was there metastasis to the femur or any other bone.

The following brief summary gives the essential clinical features of the case.

CASE REPORT

M. B., a woman, aged fifty-nine years, was admitted to Knickerbocker Hospital on June 16, 1939, with the typical physical and roentgenographic findings of an acute transcervical fracture of the right femur. The leg was placed in Russell traction, and on June 23, 1939, under nitrous-oxide-ether anaesthesia, a vitallium Smith-Petersen nail three and three-quarters of an inch long was inserted through a lateral incision.

The postoperative course was smooth, and the patient was up in a wheel chair on the third day. Because of vaginal bleeding, which developed during convalescence, a biopsy of the cervix was taken, and this showed epidermoid carcinoma. The patient was discharged on July 29, 1939, and referred for radium treatment.

Her fracture progressed satisfactorily, and in March 1940, nine months after operation, she walked without support, had a painless hip with full range of motion, and showed roentgenographic evidence of bony union. However, intra-abdominal metastasis from the cervical carcinoma developed, and she was admitted to the Home for Incurables, where she died on July 31, 1940, thirteen months after the insertion of the nail. The proximal end of the right femur was removed three hours after death.

Gross Pathology

The specimen consisted of the proximal five inches of the right femur, transfixed with a Smith-Petersen nail (Fig. 1). There was solid bony union. The articular cartilage of the head, and the ligamentous attachments at the greater and lesser trochanters were dark brown in color. The nail emerged from the center of the lateral surface of the shaft three centimeters below the base of the greater trochanter, and could be removed and reinserted, gliding inward and outward as a smooth key in a keyhole. The nail was removed, and a horizontal section cut through the center of the head, neck, and shaft.

The outstanding feature of the horizontal section was the glistening, smooth-sur-

Fig. 1
Photograph of the specimen

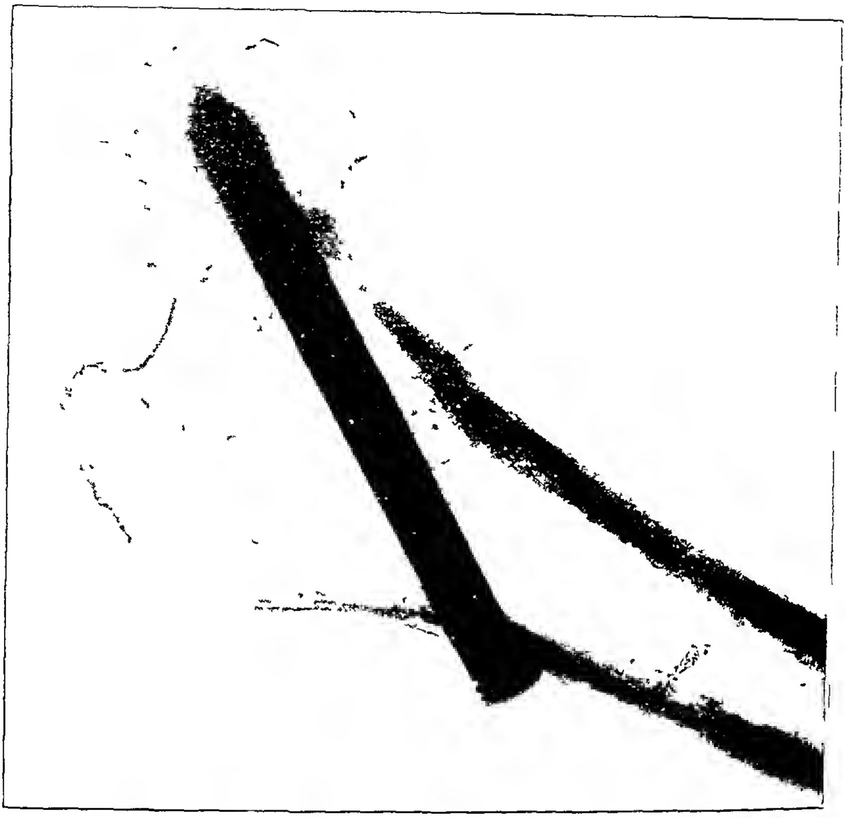

Fig. 2
Roentgenogram of the specimen

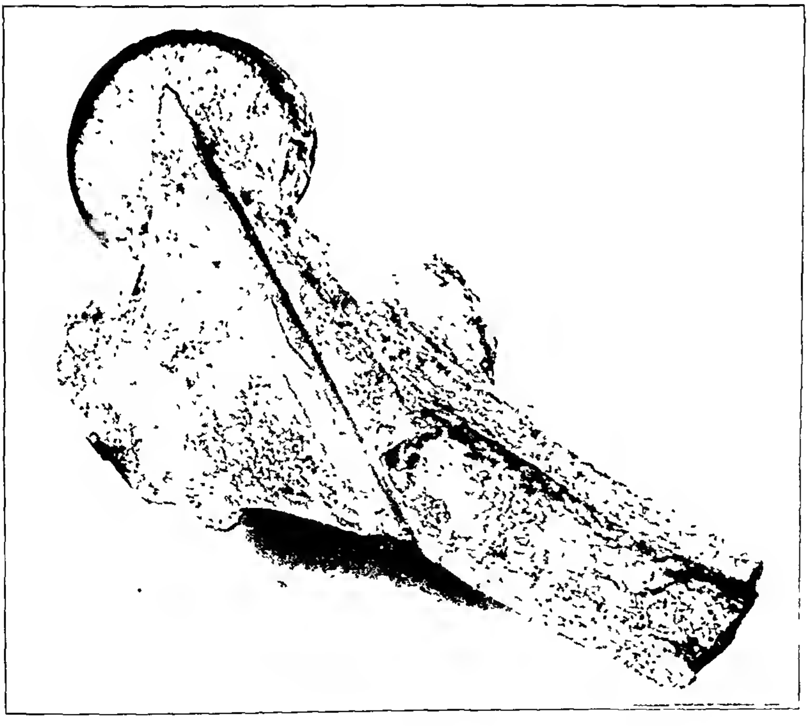

Fig. 3

Photograph of a horizontal section of the specimen. Note the glistening membrane lining the nail tract.

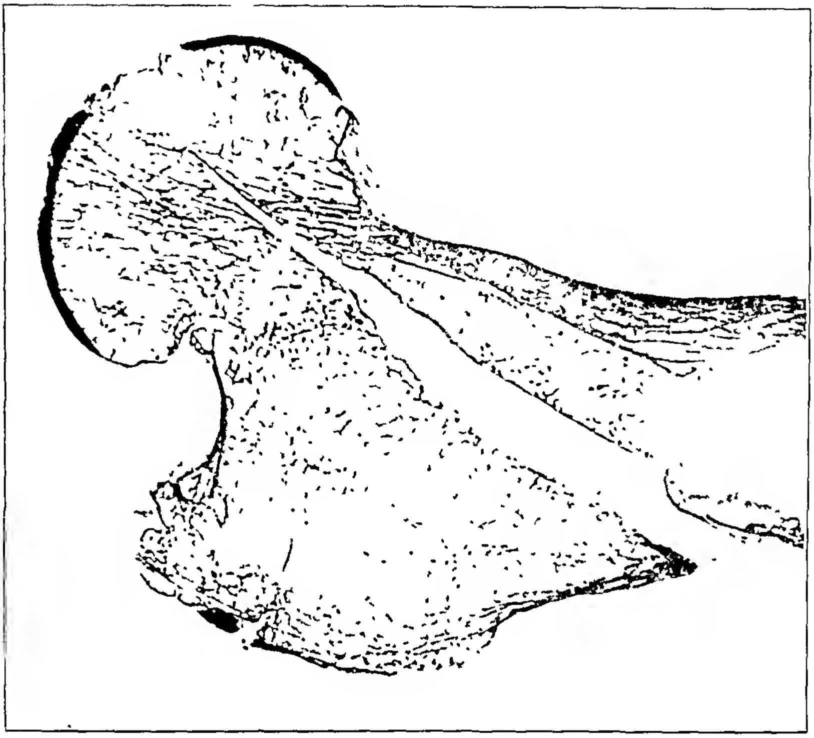

Fig. 4

Photograph of histological section of the specimen.

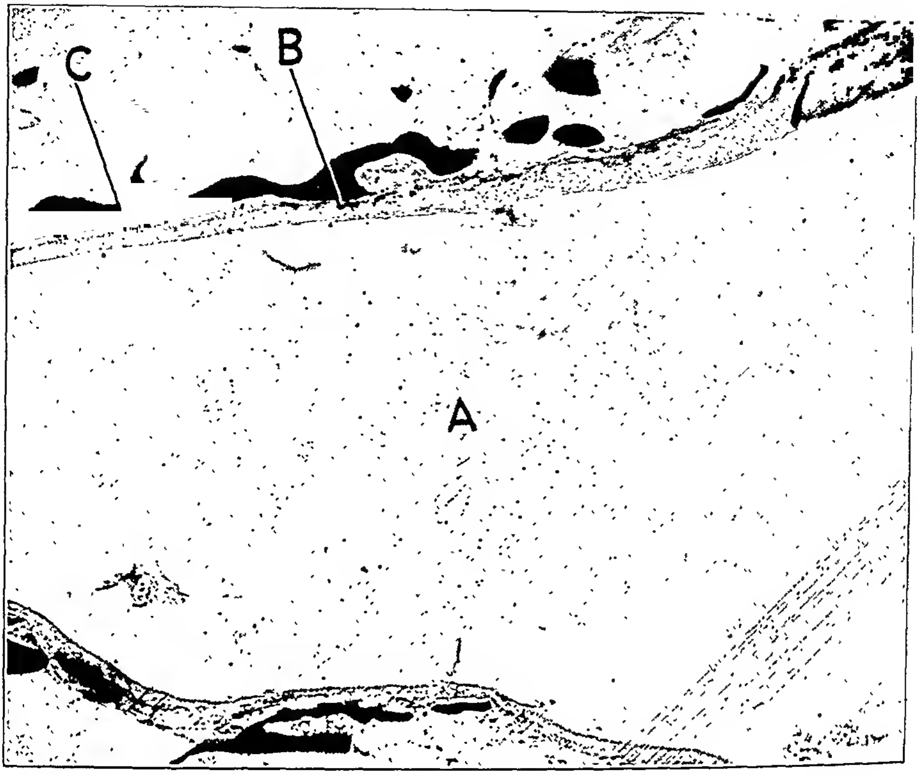

FIG. 5

Photomicrograph (× 28) of section through nail tract. A = Nail canal; B = Connective-tissue layer of membrane; and C = Bone layer of membrane.

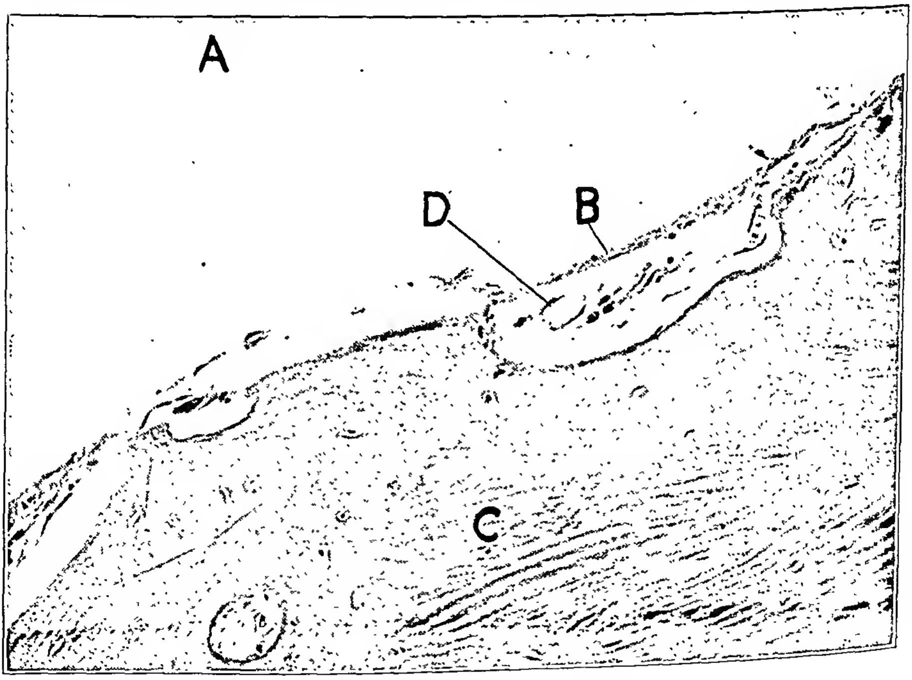

FIG. 6

Photomicrograph (× 180) of nail-canal membrane, showing one of its blood vessels. A = Nail canal; B = Connective-tissue layer; C = Bone layer along nail canal; and D = Blood vessel in connective-tissue layer.

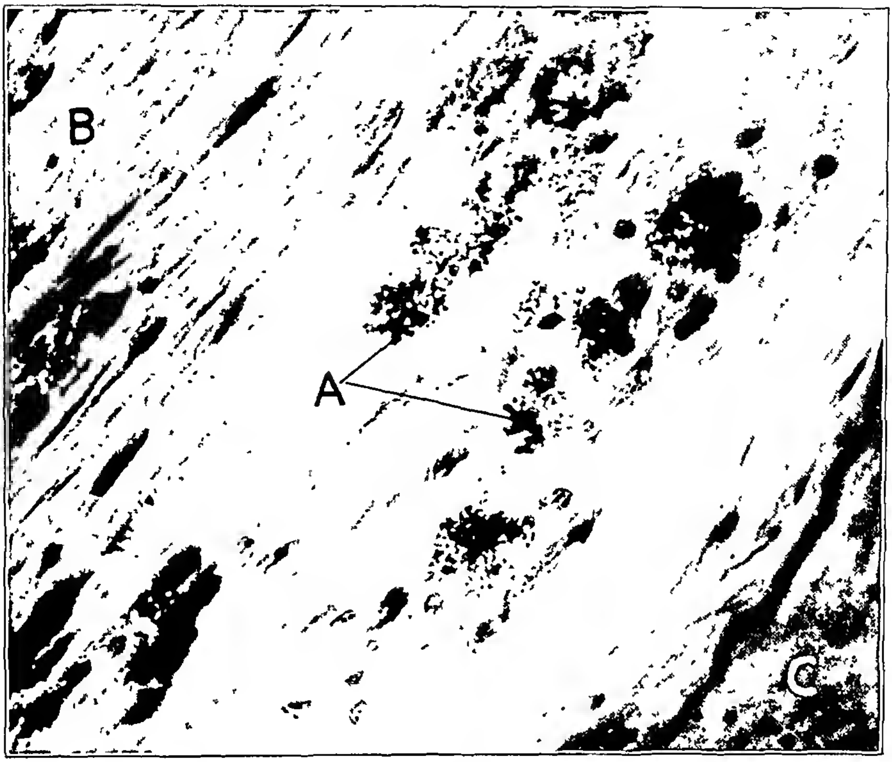

FIG. 7

Photomicrograph (× 800) of nail-canal membrane, showing pigment granules. *A* = Pigment granules in outer area of connective-tissue layer, *B* = Connective-tissue layer; and *C* = Bone layer.

faced, gray membrane which lined the nail tract throughout its entire course (Fig. 3). This membrane varied in thickness from two to three millimeters and was continuous with the adjacent bone structure. The fracture site was faintly visible and crossed the neck obliquely below the head. The head and neck showed no other gross changes. The periosteum of the neck was intact and on the shaft it dipped into the nail tract and was continuous with the lining membrane. The articular cartilage was smooth, of normal thickness, and, save for its deep brown pigmentation, showed no gross pathological changes.

Histological Study

A section of the entire specimen was made with celloidin technique, and stained with hematoxylin-eosin (Fig. 4). Smaller sections were studied with Mallory-Heidenhain and elastica van Gieson preparations.

The femoral head showed the presence of normal, living trabeculae. The nuclei of the bone cells stained, and did not suggest degeneration. As there were no necrotic trabeculae noted, this head evidently had not undergone aseptic necrosis. The articular cartilage of the head was smooth, of normal thickness, and was well preserved. It was deeply pigmented, and by special stain this pigment was shown to be iron. The cartilage cells appeared viable.

The neck showed marked subperiosteal bone formation at its inferior aspect. In the region of the fracture site there were bone trabeculae which appeared to be of recent development. In these areas of recent bone development, there were fragments of original trabeculae along some of which were rows of osteoblasts.

The Nail Tract

A most interesting feature of the section was the membrane lining the nail tract. This membrane varied in thickness at different levels, was continuous with the periosteum of the shaft, and completely lined the nail bed. It consisted of two well-defined layers: (1) an inner layer of connective tissue, and (2) an outer layer of bone trabeculae (Fig. 5).

The layer of connective tissue was composed of fibroblasts which were arranged parallel to the nail, and were continuous with the connective-tissue elements of the adjacent marrow. Numerous blood vessels were present in the outer section of this layer, and in the spaces between it and the surrounding bone lamellae (Fig. 6). These vessels were of particular interest and could be seen at various points along the nail tract. At the outer margin of this connective-tissue layer, groups of small, deeply stained pigment granules were seen. Some of these granules appeared to lie within macrophages, others were extracellular, lying in clusters between the fibroblasts. These granules were present only adjacent to the trabeculae or spongiosa, never near the nail. By special stain the pigment was shown to be iron (Fig. 7).

The bone layer consisted of trabeculae laid down along the nail tract. The bone trabeculae did not surround the tract throughout its entire length, there being intervals where the fibrous tissue layer was in contact with the spongiosa with no intervening lamellae. However, in the region of the head, the osseous layer was present as an envelope surrounding this portion of the nail tract. Typical of the bone layer were trabeculae situated at right angles to the tract. There were some areas in this layer in which there had been an ingrowth from the fibrous-tissue layer, and which may have represented fibrous absorption of the bone trabeculae. These areas, however, were few.

DISCUSSION

The pigment granules and surrounding cells along the nail tract have not been described in the cases reported in the English literature. However, Felsenreich described them in considerable detail, and they are considered a constant finding. They are known as "rust granulomata" and the statement is made that the pigment is a form of organic iron derived from the iron of the stainless-steel nail.

In the case here reported, the pigment is definitely iron; but, since a vitallium nail containing no iron was used, the pigment could not have come from the nail. It would seem that the iron pigment was derived from broken-down red blood cells, possibly resulting from the continued trauma of the nail forced against the surrounding trabeculae and marrow.

The presence of pigment in the capital cartilage and trochanters occurring in this case has not been previously reported, and is probably an unusual finding. It may be a phase of cartilage degeneration.

CONCLUSIONS

1. Because of the presence of massive bone lamellae along the nail tract, it can be stated with assurance that, contrary to former belief, certain metal alloys introduced into bone do not prevent bone formation.

2. The new blood vessels in the connective tissue of the nail tract seem to be an increased blood supply, and, when carried across the fracture site, may be a factor in the better nutrition of the head. This interpretation was first suggested by Engel.

3. The nail causes the development of a fibrous-tissue cavity of

considerable size, not unlike a bone cyst, which traverses the head and neck.

4. If the theory of the origin of the pigment granules is correct, the nail in its canal causes trauma to the surrounding spongiosa and bone lamellae.

The author wishes to thank Herbert Bergamini, M.D., C. Howard Hatcher, M.D., Henry Horn, M.D., and William C. Clarke, M.D., for their help in this case.

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TWO UNUSUAL INJURIES OF THE WRIST

BY VERNON L. HART, M.D., MINNEAPOLIS, MINNESOTA

The writer wishes to record two unusual injuries of the wrist resulting from direct violence over the volar aspect of the carpus.

The first injury is a fracture of the ridge of the greater multangular bone or trapezium which gives attachment to three of the intrinsic muscles of the hand and the transverse carpal ligament.

The patient's injury resulted from a fall upon the volar surface of the wrist, while he was going down a steel stairway, and was considered a sprained wrist since the routine roentgenograms were normal. Two weeks after the injury a vertical roentgenogram of the wrist was studied because severe pain and tenderness over the volar aspect of the greater multangular bone persisted. The roentgenogram (Fig. 1) demonstrated a fracture of the ridge of the greater multangular bone which forms part of the radial border of the carpal canal. Adequate immobilization of the wrist, limited use of the hand at work, and frequent warm hand baths resulted in normal return of function after several more weeks.

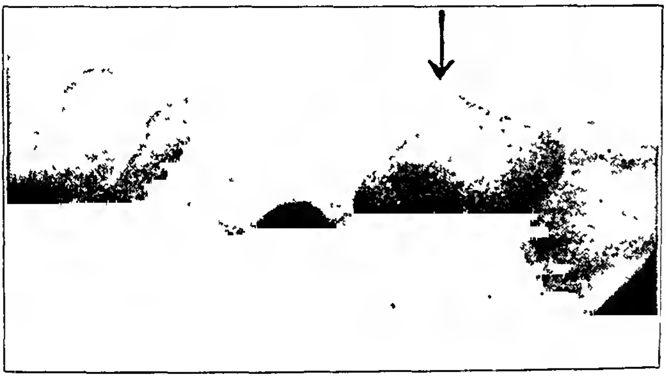

FIG. 1

Vertical roentgenogram of the wrist, revealing a fracture of the ridge or tuberosity of the greater multangular or trapezium bone which forms part of the radial border of the carpal canal.

FIG. 2

Vertical roentgenogram of the wrist demonstrating the bones of the carpus, which form the borders of the carpal canal, and the relationship between the ulnar nerve and the hook of the hamate or unciform bone and the pisiform bone. The ulnar nerve (indicated by white circle) crosses over the tip of the hook of the hamate bone and, in the normal hand, can be felt slipping over the bone when pressure is made with the thumb of the opposite hand about two centimeters distal and radial to the pisiform bone.

The second injury is a scar-tissue, ring constricture of the ulnar nerve where it passes over the hook of the hamate or unciform bone which forms a part of the ulnar border of the carpal canal (Fig. 2).

The volar aspect of the patient's wrist was injured when a barrel weighing several hundred pounds rolled upon it. The injury was considered

to be a sprained wrist for a period of seven months. During this time the patient could not work because of great pain and tenderness in the region of the hypothenar eminence. Several physicians had treated the patient, and many routine roentgenograms were normal. Possible diagnoses of neurosis and malingering were also considered. No relief of symptoms was obtained by immobilization and physical therapy. Pressure applied directly over the hook of the hamate bone and the ulnar nerve, or a finger's breadth distal and radial to the pisiform bone, caused severe local pain and radiating pain into the fourth and fifth fingers. There was moderate, but definite swelling of the hypothenar eminence, and hypaesthesia over the distribution of the superficial branch of the ulnar nerve to the fourth and fifth fingers.

The volar branch of the ulnar nerve crosses the transverse carpal ligament on the radial side of the pisiform bone, and ends by dividing into a superficial and a deep branch. The superficial branch is purely cutaneous and supplies the skin on the ulnar side of the hand, the palmar aspect of the fifth finger, and the palmar surface of the ulnar half of the fourth finger. The deep branch is purely motor.

Under local anaesthesia the ulnar nerve was exposed directly over the prominent hook of the hamate bone. (At this level the ulnar nerve divides into the deep and superficial branches.) Immediately distal to the division there was a marked constriction of the superficial branch of the nerve caused by a thick ring of scar tissue which was adherent to the free end of the hook of the hamate bone. The nerve was oedematous and swollen directly proximal to the constriction. Excision of the ring of scar tissue and a neurolysis of the affected portion of the nerve resulted in complete relief of the patient's disability.

ROENTGENOGRAPHIC RECOGNITION OF SYNOVIOMA

BY A. P. AITKEN, M.D., BOSTON, MASSACHUSETTS

Within the past few years, there has been described in the literature the rather uncommon tumor known as synovioma. Unfortunately this term has been applied to all forms of intracapsular tumors, either benign or malignant, notably the more common xanthoma. The tumor to which the author refers, however, is one derived primarily from the cells of the synovial lining, and characterized by the formation within the tumor of spaces lined with synovial cells. The tumor is said by pathologists to resemble closely an angioma, and to be often mistaken for it. This neoplasm is a sarcoma, and is either highly malignant or potentially so. Although the tumor is derived from synovial cells, and may thus arise from either a joint or a bursa, it may be found to be entirely extracapsular, and to have no apparent association with either of these structures. However, it is usually found in close proximity to a joint. Clinically, this neoplasm is seldom diagnosed prior to biopsy and microscopic study. When a soft-tissue tumor mass develops in the neighborhood of a joint, the diagnosis is usually one of the benign tumors—such as lipoma, fibroma, or cyst of the semilunar cartilage or bursa. When such masses show calcification, the most common diagnosis is that of a calcified bursa. That such a mass may be highly malignant, or potentially so, is not even suspected, in most instances. Any evidence, then, which might be of aid in the diagnosis of this tumor, is of great value.

In a recent article, Lewis [1] has described roentgenographic evidence which he believes is pathognomonic of this tumor. Although this evidence was present in only 25 per cent. of his cases, the author believes it should be called to the attention of the orthopaedic surgeon. Lewis states, "Near a joint, and sometimes involving the joint, is seen a rounded, sometimes rather lobulated, sharply defined, soft-tissue tumor mass. No differential diagnosis can be made on such a mass in itself; but when in the mass is found a scattered and irregular deposit of amorphous lime, we have learned that a provisional diagnosis of synovioma is justified." The following case demonstrates clearly this roentgenographic evidence as described by Lewis.

G. R., aged twenty-one, entered the Lawrence Clinic, Lawrence, Massachusetts, in February 1940, complaining of a painful swelling on the lateral aspect of the right knee. Two years previously, while playing basketball, he had been kicked in this region. The knee became acutely swollen and painful. After a few days of rest the pain disappeared, and the swelling largely subsided. Since this accident, however, a mass the size of a quarter had remained. This mass was painless until six weeks prior to admission. The boy stated that, since the onset of pain, he thought the mass had grown slightly larger. On examination a mass, the size of a plum, was found over the lateral aspect of the knee joint, just lateral to the patella. It was not tender, but it was soft, and portions of it seemed semifluctuant. The skin and subcutaneous tissues were freely movable over it, but the mass was firmly adherent to the capsule of the

FIG. 1-A

FIG. 1-B

Roentgenograms show amorphous areas of calcification in the anterolateral aspect of the knee joint with definite extension into the joint spaces as shown in the anteroposterior view. There is no evidence of bone involvement.

joint. There was a flexion deformity of 30 degrees, with considerable quadriceps atrophy. There was no free fluid present within the joint, and no capsular thickening was present elsewhere about the joint. The roentgenograms (Figs. 1-A and 1-B) revealed the mass, and within it a diffuse amorphous-lime deposit. This deposit clearly extended into the infrapatellar fat pad. The roentgenograms were shown to numerous roentgenologists and orthopaedic surgeons, but no definite diagnosis was made. It was thought that it might be a calcified hematoma, as the mass was noticed after definite trauma to this region.

At operation the tumor was found to be well encapsulated, was of grayish color, and very friable. On dissection laterally, however, the mass was found to have invaded the fascia lata. Medially the tumor was easily lifted off the tibia and lateral condyle of the femur. At the lateral border of the patella, however, the tumor extended into the infrapatellar fat pad, and here the synovial membrane was involved. The synovial membrane in this area was excised, and as traction was made on the mass on dissection, the whole tumor suddenly separated from the surrounding fat pad, showing a cylindrical mass of tumor, about one and one-half inches in length, which had extended through the fat pad to the medial side of the knee joint. This section apparently was also well encapsulated. Although the nature of the tumor was not recognized, its friability and tendency to invasion led to the belief that the tumor was malignant.

The tumor was first reported as an angioma. Dr. Beach Hazard, however, reported the mass as a malignant synovial sarcoma. His report is as follows:

"*Gross Examination.* The specimen consists of approximately four irregularly shaped masses of tissue received fixed in formalin. These measure up to three and five-tenths centimeters in diameter. On section they are found to be of white color, of rather firm consistency as received, and several present a few yellowish patches. One

fragment of tissue is a semilunar cartilage, along the margin of which is a somewhat blood-stained but otherwise grayish-white tissue.

"*Microscopical Examination:* The tissue masses are formed for the most part of small dark-staining cells of spindle shape, occasionally somewhat curved, which occur in rather broad sheets, present occasional pinkish hyaline zones, and with frequent zones of calcification. In addition to this picture there are occasional spaces, irregular in contour and with papillary projections extending into them at times, which are lined by epithelial-like cells of cuboidal or low columnar type. Many mitoses are present in some regions. A section through the semilunar cartilage shows the margins to be invaded by spindle-shaped cells as described.

"*Diagnosis:* Synovioma, with extensive calcification."

Because of the malignant nature of the tumor, amputation was advised, but refused. The boy was then seen once a month for seven months. During that time he had no pain and there was no evidence of recurrence either clinically or by roentgenograms. Four weeks after his last visit, in October 1940, the boy again returned complaining of pain. Examination at that time revealed the presence, in the scar, of three small tumor masses about one and one-half inches apart. There was no fluid in the knee joint, and the roentgenograms were negative. One week later, amputation at mid-thigh was performed. At that time not only had the three areas increased in size, but a fourth mass had made its appearance. Examination of the amputated knee showed numerous tumor masses within the joint, and several large masses in the popliteal space, two of which had extended well into the lumen of the popliteal vein.

Six months after amputation the boy was well, and there was no clinical or roentgenographic evidence of pulmonary metastasis, but on July 19, 1941, examination showed multiple metastases to the lungs.

SUMMARY

Synovioma or sarcoma of the synovial membrane is a rather rare form of tumor. Its occurrence is, however, being reported in the literature with increasing frequency. The diagnosis is seldom made clinically.

This case is presented to illustrate the roentgenographic appearance of this tumor as described by Lewis, and to call it to the attention of the orthopaedic surgeon.

[1] Lewis, R. W.: Roentgen Recognition of Synovioma. Am. J. Roentgenol., XLIV, 170, 1940.

REMINISCENCES

Introductory Remarks at the Annual Meeting of the Orthopaedic Section of the Royal Society of Medicine *

BY ROYAL WHITMAN, M.D., NEW YORK, N. Y.

This Meeting enables me to establish what may be a record of active service, since there is an interval of sixty years between my first appointment, as an intern, and my last, as Consultant to the American Hospital in Britain.

Furthermore, as the only survivor of the first regular meeting of The American Orthopaedic Association, held in 1887, it will appear that my active life covers practically the entire period of the development of the specialty.

The term "orthopaedic surgery" was suggested by a New York surgeon, Valentine Mott, to signify the combination of operative and mechanical surgery, which, he predicted, would inaugurate a new era in the healing art,—a prediction that has been amply justified.

At this first meeting, the amalgamation of what until then had been antagonistic forces was far from complete. The President was an orthodox mechanician, permitting no operative treatment at the hospital that he controlled, because it would prevent the normal development of what he called "mechanico-therapy". He was a militant upholder of the traction treatment of hip disease, designed to permit motion without friction and thus to preserve the nutrition of the limb and to prevent ankylosis. He felt constrained, therefore, to use his influence to oust a colleague from his post at St. Luke's Hospital because he had been infected by the fixation heresy of Thomas.

At this meeting only a small contingent could qualify as orthopaedic surgeons. The outstanding representative of the new order was Dr. E. H. Bradford, whose son is now a member of the staff of this Hospital. He founded the Boston School, which has made so many valuable contributions to the development of the specialty.

The surgery of the period was purely corrective in scope. Constructive surgery was a later development. Constructive surgery implies the readjustment of the latent power of a disabled member to restore as far as may be its most important function,—primarily locomotion.

I think myself fortunate that, having had no instruction in the new departure, I was obliged to depend on my own observations and deductions. Thus unwittingly I followed the footsteps of John Hunter.

I had an unusual opportunity for self-education, for I worked for forty years in a hospital where the patients were not restricted by artificial

* A few months ago Dr. Whitman, who has resided in London for several years, was appointed Consulting Surgeon to the American Hospital in Britain, and these remarks are part of an address given at a meeting held at that Hospital on June 28, 1941.

conventions, combining in a continuous service both the out-patient and in-patient departments.

From this experience I came to the conclusion that the one who had analyzed the disability and planned the reconstructive procedure, who had carried it out according to specifications, and who by constant oversight had detected and supplemented its weak points was most competent to judge of its relative utility. These conclusions were so often at variance with what is called the consensus, that for the greater part of my active life I have been a member of the opposition.

Looking backward, I recall a dinner given by the Tavern Club to James Russell Lowell, lately returned from service at the Court of St. James, on his seventieth birthday, at which Oliver Wendell Holmes welcomed him to "life's fair field beyond the seven-barred gate". I continued in active work long after entering this enclosure, and I now find myself opposed to the statement of the Psalmist to the effect that those who reach eighty years can expect only labor and sorrow; for, since reaching this landmark, I have had the privilege of participating in the Battle of Britain, at least to the extent of having my windows broken. Moreover, I have received the great honor of election as Honorary Fellow of the Royal College of Surgeons and of the Royal Society of Medicine. This recognition of my work was the more appreciated because its foundation was laid in London, in the intensive study of anatomy in Cook's School, established in St. George's graveyard, and I am glad to have the opportunity to pay a belated tribute to the memory of the best teacher that I have ever known.

A SIMPLE APPLIANCE FOR THE CORRECTION OF GROSS DISPLACEMENT IN TIBIAL FRACTURES

BY H. K. CHRISTIE, M.CH.(N.Z.), F.R.C.S.(ENG.), F.R.A.C.S., WANGANUI, NEW ZEALAND

Major N.Z.M.C., Orthopaedic Surgeon to No. 1 N.Z. General Hospital, Middle East Force

The displacements which result from fractures of the long bones include shortening or overlap, lateral displacement, angulation, and rotation. All of these must be kept in mind to ensure accurate reduction and good functional repair.

These four deformities are to some extent interdependent, because angulation causes further shortening, while overlap is prone to cause "cross union" with the loss of movements of normal rotation. Shortening and angulation are of particular importance in the lower limb in relation to ambulation, and lateral displacement is a source of non-union.

Much ingenuity and unremitting care have been expended by orthopaedic surgeons in devising apparatus for the prevention and correction of such deformities, and, although a certain degree of standardization of methods has resulted, there is still room for improvement in these methods.

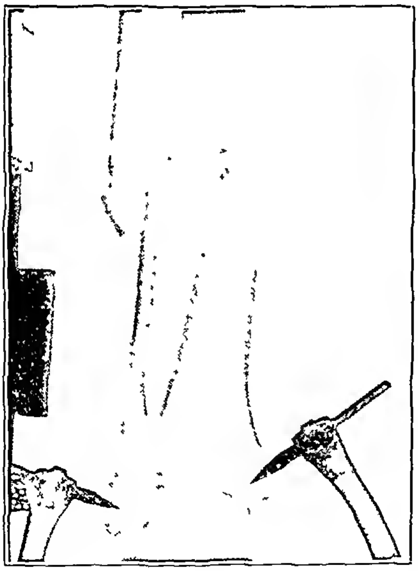

FIG. 1

Roentgenogram taken October 9, 1939, shows lateral displacement and overlap, and the presence of callus between the bone ends. The ice-tongs caliper has been placed too low.

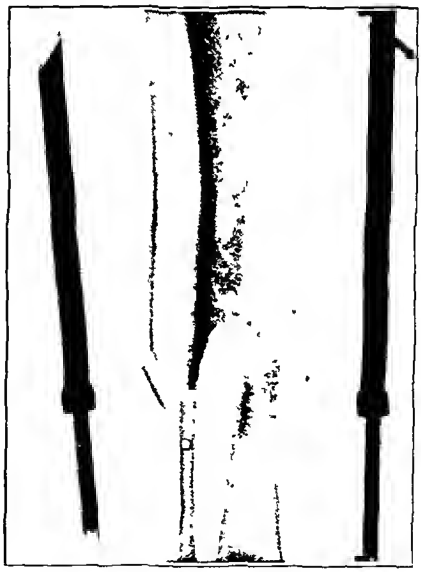

FIG. 2

Roentgenogram taken October 20, 1939. Steinmann pins have been inserted, and bone distractors of the Hey Groves type applied. Half the shortening was corrected at once, and the other half during the following week.

Much of the fracture apparatus in present use has certain disadvantages: (1) It is cumbersome and costly; (2) it is not self-contained (that is, it depends on weights and pulleys attached to frames and bedsteads); (3) it does not provide, in one apparatus, exact control of all three deformities and, at the same time, sufficient traction to correct fractures imperfectly aligned and already partly united.

In planning the apparatus used in the case here presented, it was the author's aim to overcome these defects as much as possible.

Case 1. On October 9, 1939, the patient was admitted to the Fracture Clinic of the Wanganui Hospital, New Zealand, four weeks after an accident, with unreduced compound comminuted fractures of the shafts of the tibia and fibula and gross shortening of one inch (2.5 centimeters), lateral displacement, and much callus separating the bone ends. An ice-tongs caliper was in position (Fig. 1).

It was necessary to provide powerful distraction of the fragments and lateral correction, in spite of the resistance of spongy callus.

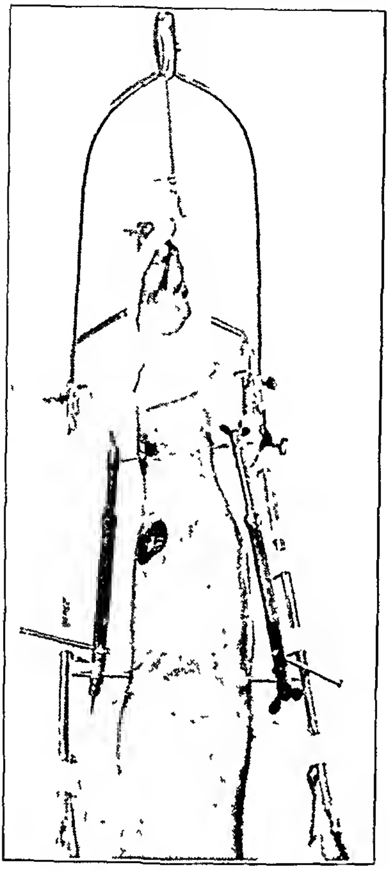

Fig. 3

Fig. 3

Showing use of distractors of the Hey Groves type for compound fracture with overlap and shortening.

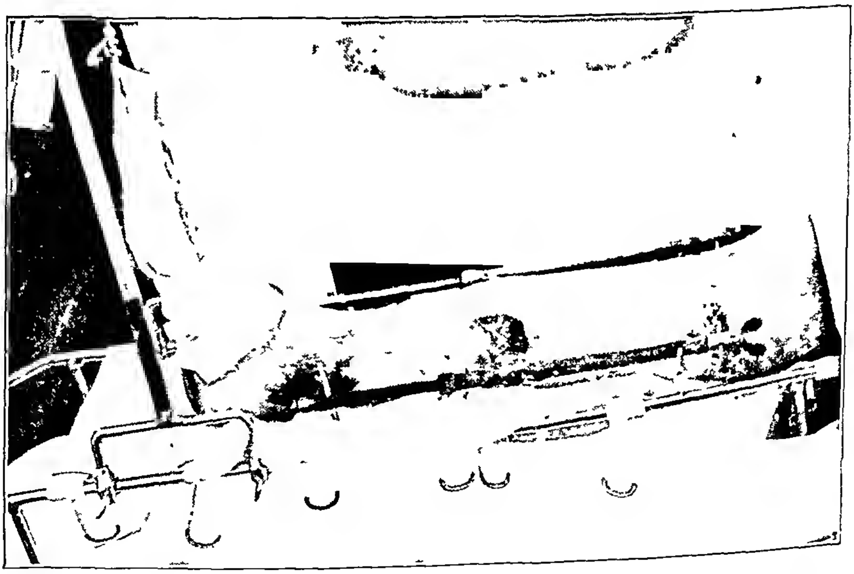

Fig. 4

Side view shows the Steinmann pins pushed apart by the lateral screws, thus correcting the shortening, but not the lateral displacement. Necrotic bone can be seen in the wound.

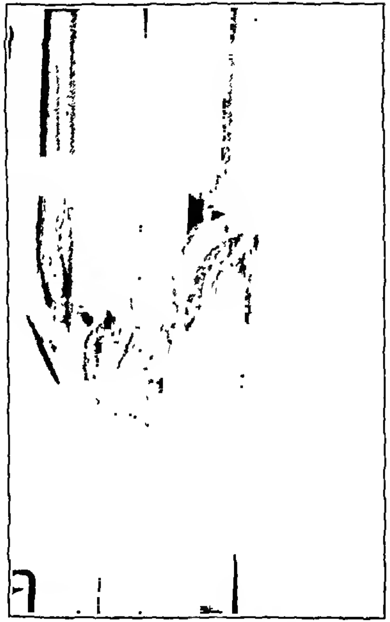

FIG. 5

November 1, 1939. Correction of the lateral displacement was obtained in spite of five weeks' callus, by the pressure of the shouldered pins. After correction, a close-fitting plaster was applied.

A sequestrum can be seen at the end of the lower fragment.

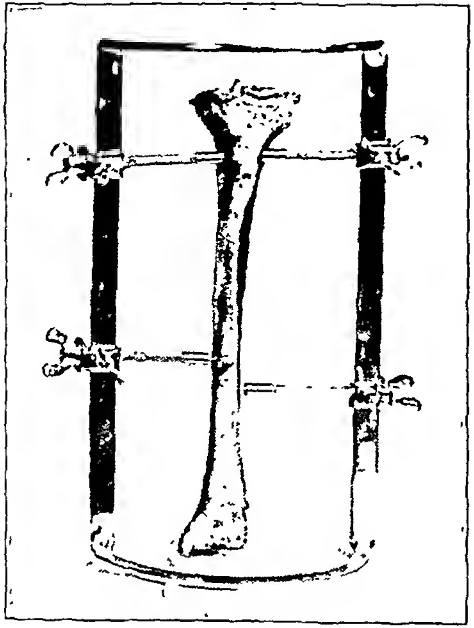

FIG. 6

In the apparatus for lateral correction, the shouldered pins slide on rigid flat side bars, which may be clamped in any position and then advanced by turning the winged nuts at the side. *The apparatus should be about eight inches in length.*

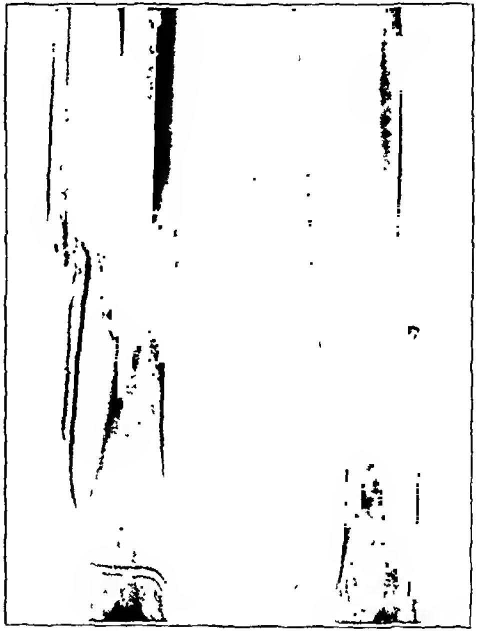

FIG. 7

March 7, 1940. The sequestra have been removed, and there is firm union in good position. Both the shortening and the lateral displacement have been fully corrected.

On October 20, 1939, Steinmann pins and distractors of the Hey Groves type (Figs. 2, 3, and 4), in association with a Braun splint, were used to restore length. Restoration of half an inch (1.25 centimeters) was obtained immediately, and the remaining half inch during the next six days by daily turns of the screws.

Lateral correction was obtained November 1, 1939, under a local anaesthetic, by making small slits in the skin over the tibia and introducing the shouldered ends of the "lateral correctors" (Figs. 5 and 6). The powerful thumbscrews were turned, crushing the callus and easily correcting the lateral displacement. An unpadded plaster was applied.

A cortical sequestrum seen in Figure 5 was removed March 7, 1940, after union had become firm. The result is shown in Figure 7.

The apparatus is also useful for the gradual lengthening of a shortened limb after a corrective osteotomy.

A smaller distractor of the same type may be used for the correction of double fracture of the shafts of the radius and ulna,—the wires being passed through the olecranon and the lower ends of the radius and ulna.

Care must be exercised not to overdistract the bones, but this will not occur if roentgenographic control is used.

THE CONSERVATIVE TREATMENT OF SERRATUS PALSY

BY JOSEF WOLF, M.D., DAVENPORT, IOWA

As with other types of muscle palsy, the isolated paralysis of the serratus anterior can be divided into two stages: the acute paralysis from which recovery is possible, and the late stage in which the paralysis is permanent. The same kind of orthopaedic appliance cannot be used for both stages.

For the former, the purpose is to splint the muscle in a position of complete relaxation, which eliminates the action of its opponents and, thereby, favors recovery.

According to Horwitz and Tocantins, derotation of the scapula is the most important means of restoring the tonicity of the paralyzed serratus. Their brace for serratus palsy consists of a celluloid bucket, which is fastened to a pelvic rest, and receives the flexed elbow, thus eliminating the influence of the weight of the arm upon the shoulder and the antagonistic action of the biceps muscle. Other orthopaedic appliances for acute serratus palsy are Mackenzie's sling about the neck suspending the arm by the wrist, and Faucor's "cloverleaf sling", encircling the unaffected shoulder, the neck, and the wrist of the affected side. Berkheiser and Shapiro use a plaster spica, and Fitchet an aeroplane splint. All devices but that described by Horwitz and Tocantins only counteract the weight-bearing, and the action of the biceps muscle, but do not derotate the scapula.

FIG. 1
Paralysis of the left serratus anterior muscle with winging of the scapula.

An appliance for the late stage of serratus palsy, in which the paralysis is permanent and operative treatment cannot be undertaken, (1) must allow complete use of the arm, (2) must press the winged scapula in its normal position against the wall of the chest, and (3) must prevent its rotation. Thomson and Miles have devised a direct pressure pad over the scapula which, however, does not derotate the scapula.

The brace which is here described fulfills all three requirements. It consists of a metal pad over the protruding scapula, which is molded deep enough to receive the triangular shoulder blade and to hold it with the inner border parallel to the spine, and a second metal pad over the unaffected scapula. Both metal pads are connected by three metal springs. The lowest of these springs extends over the two pads and anteriorly under the armpits on both sides, forming axillary crutches as in standard

body braces, and ending in two spoons placed in the infraclavicular fossae. The function of the spring is to press the pad on the affected side, and, with it, the winged scapula, against the ribs, while the deep molding of this pad affords perfect derotation. To prevent upward sliding, the apparatus is anchored to an abdominal girdle with two posterior straps They are counteracted by two leather straps which extend over the shoulders from the upper brims of the scapular pads and are fastened to the infraclavicular spoons, thereby holding the brace safely in place. The pads and axillary crutches are padded with felt and covered with chamois skin.

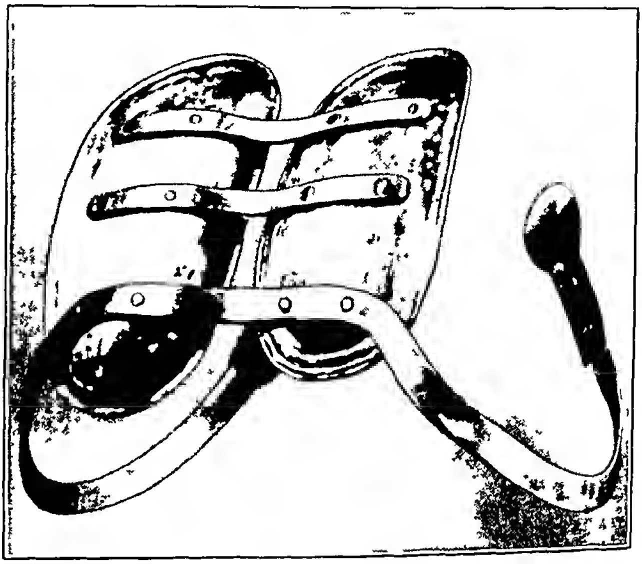

Fig. 2

Metal part of the brace. Note larger and deeper metal pad for the left, winged, shoulder blade. The lowest spring is brought forward as axillary crutches on both sides

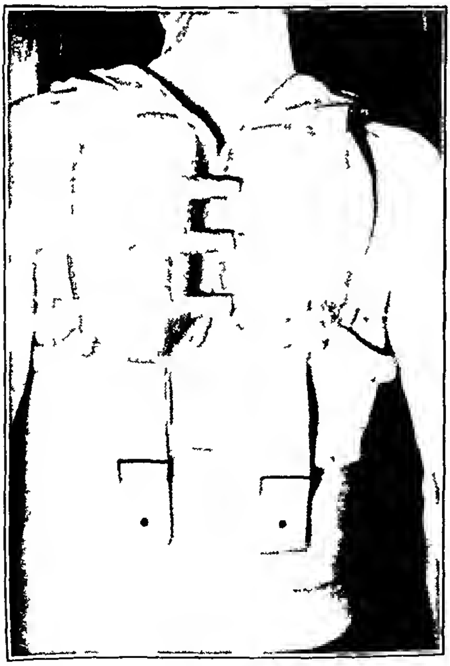

Fig 3

Back view of the brace which is fastened to an abdominal belt to prevent upward sliding.

Fig. 4

Front view. Note the anterior ends of the axillary crutches as spoons pressing into the infraclavicular fossae

A machinist, fifty-seven years old, for whom this appliance was devised, incurred the serratus palsy immediately after an operation for ruptured gastric ulcer in September 1940 (Fig. 1). He was first seen seven months later, at which time the chances for recovery of the paralyzed muscle were considered poor. An operation was refused. With the brace just described (Figs. 2, 3, and 4), the patient can raise his arm over the horizontal line, and can forcefully push his hand forward. It enabled him to resume his former work in a power house, which requires the shifting of heavy switches.

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LETTER TO THE EDITOR

To the Editor:

This letter has been suggested by the conclusions of McCarroll and Crego in the abstract of their paper on the Early Treatment of Anterior Poliomyelitis*, presented at the meeting of The American Academy of Orthopaedic Surgeons in January. These are, in effect, that the result is dependent on the amount of destruction that has taken place in anterior horn cells, and that the type of early orthopaedic measures has little or no effect on the course of the disease and alters little, if any, the degree of residual paralysis. The authors support this conclusion by the observation of six different methods, the last of which is no treatment.

I am quite in accord with the main proposition but not with the minor conclusion, for in my opinion the immediate treatment has a most important influence on the course and effects of the disease in its relation to the patient. This treatment should be rest, to relieve pain and to prevent deformity, which may be best assured by plaster splinting if properly applied. The material is always at command and is under the control of the one who applies it. Although the final paralysis is determined by the character of the disease of the cord, its functional effect on the individual is greatly influenced by the quality of the treatment. The purpose of the treatment during the primary stage is to prevent deformity and to assure the attitude most useful in locomotion. In the second period, the most effective means of developing latent power is functional use; and by constructive surgery one may so adjust the mechanics as to assure the best opportunity for its development.

In order to avoid misunderstanding, I shall limit my comments to two types of cases,—namely, paralysis of the calf muscles and paralysis of the anterior thigh group of muscles. When it may appear that the repair of the disease of the cord has been accomplished, the most effective treatment of its secondary effects is locomotion on the protected limb. When the degree of permanent paralysis has been clearly determined, one may consider constructive surgery from the standpoint of promoting ease and security in locomotion. In the first instance, by far the most important consideration is to restore the stability of the foot, since the most disabling form of partial paralysis is loss of resistance to dorsal flexion. For this, astragalectomy with backward displacement of the foot is by far the most effective remedy, and its effect in stimulating the nutrition and growth of the limb is often surprising. Another effective aid is transplantation of the biceps for paralysis of the anterior thigh group. It may be noted, however, that it is of no value unless resistance of the forefoot is restored, which is essential to locking the knee in extension. The transplanted biceps may then restore a practically normal gait, since it enables the patient to swing the leg forward when the foot is lifted. As compared to these fundamental principles, other treatment is of subsidiary importance.

In conclusion, it may be emphasized that the paper referred to considers only the negative effects of physiotherapy on the residual paralysis, while my comments are concerned with the influence on the final functional result of positive, immediate, and consecutive treatment supplemented by surgical intervention.

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* See page 851 of this issue of *The Journal*.

END-RESULT STUDY OF THE TREATMENT OF IDIOPATHIC SCOLIOSIS

REPORT OF THE RESEARCH COMMITTEE OF THE AMERICAN ORTHOPAEDIC ASSOCIATION*

The Research Committee of The American Orthopaedic Association, aided by a grant from the Alfred I. duPont Institute of The Nemours Foundation, has undertaken a study of the methods and end results of treatment of idiopathic scoliosis in an effort to establish the present status of this condition, and to clarify, in so far as possible, what can be expected from the present methods of treatment. Lateral curves, due to congenital anomalies, poliomyelitis, empyema, and any other recognizable disease process, were excluded from the study.

Cases were reviewed from an end-result standpoint in sixteen orthopaedic clinics throughout the country. This included a study of 425 case histories, roentgenograms, and photographs. An end-result physical examination was made (by L. N.) of 127 of the patients. The Committee wish to express their appreciation for the cooperation and valuable assistance given in this survey by the Orthopaedic Departments of the following clinics: Shriners' Hospital for Crippled Children in San Francisco; the Orthopaedic Hospital in Los Angeles; Carrell-Girard Clinic and Texas Scottish Rite Hospital for Crippled Children in Dallas; Crippled Children's Hospital in Oklahoma City; Willis C. Campbell Clinic Hospital in Memphis; University Hospitals in Iowa City; Mayo Clinic, Rochester; University Hospital, Ann Arbor; Hospital for Sick Children, and Toronto General Hospital, Toronto; Hospital for the Ruptured and Crippled, New York Orthopaedic Dispensary and Hospital, and Hospital for Joint Diseases in New York; Shriners' Hospital for Crippled Children in Philadelphia; Johns Hopkins Hospital and Children's Hospital School, and The James Lawrence Kernan Hospital and Industrial School of Maryland for Crippled Children, in Baltimore; Shriners' Hospital for Crippled Children in Springfield; and Children's Hospital, and Massachusetts General Hospital in Boston.

TABLE I

ETIOLOGY

Probable Etiology of Idiopathic Scoliosis	Clinicians Supporting View
Curvature is the result of failure of muscular and skeletal systems to maintain a balance during the rapid growth period, and is associated in some way with an endocrine or metabolic disturbance.	4
Curvature is primarily the result of muscle imbalance, the source of the imbalance being unexplained, but possibly being postural fatigue, an unrecognized poliomyelitis, or some similar process..............	7
Curvature is the result of a growth disturbance at the epiphyseal plate of the vertebrae, possibly related to an osteochondritic process or to epiphyseal trauma with an associated deficiency, either metabolic or dietary..	6
Curvature is the result of postural faults, acquired during growth and fatigue of adolescence, prolonged sitting in school, etc., which gradually lead to a fixed deformity................................	6
Curvature is an exaggeration of physiological deviation occurring during normal gait, being greater toward the right side due to the weight of organs, and passing beyond normal limits in the presence of some body insufficiency..	2
Hereditary and environmental factors are felt to be definitely contributory	2

* Read at the Fifty-Fifth Annual Meeting of The American Orthopaedic Association in Toronto, Canada, June 10, 1941.

incent's Hospital.
[illegible]

TABLE II
NATIONALITY
(252 Cases)

	Per Cent.		Per Cent.
Jewish	27	Norwegian	3
"American"	25	Greek	2
Italian	14	Syrian	2
German	7	Japanese, Scotch, Lithuanian, French, Armenian	4
Negro	6		
English	4		
Polish	3		
Irish	3		

An expression of ideas concerning the etiology of the idiopathic type of scoliosis was obtained from the men in the various clinics, and these may be divided into five general groups, as shown in Table I. Research is being carried on by some of these men at the present time, with the hope that some more effective program of prophylaxis and treatment may be worked out.

Data on nationality was available in 252 cases, as shown in Table II. The predominance of cases of the Jewish race may be due to the fact that the large Eastern cities (New York, Baltimore, and Boston) contributed substantial numbers of cases to the series, and there is a high percentage of Jewish population in these cities.

TABLE III
COMPLAINT

		Per Cent.
Cosmetic		92
Curvature	57	
High or prominent shoulder	27	
Prominent hip	8	
Backache		8
Total		100

Girls predominated four to one, there being 82 per cent. females and 18 per cent. males. Incidence of curvature in others of the same family amounted to 7 per cent. (twenty-seven cases of the 386 in which family history was recorded).

The presenting complaint was of cosmetic deformity in 92 per cent. of the cases, and of backache in 8 per cent. (Table III). In the group of thirty-six patients with backache, only 6 per cent. were less than twelve years of age; 22 per cent. were between twelve

TABLE IV
AGE OF ONSET
(404 Cases)

Age (*Years*)	No. of Cases	Age (*Years*)	No. of Cases	Age (*Years*)	No. of Cases
2	1	8	14	14	55
3	1	9	18	15	26
4	2	10	34	16	8
5	8	11	46	17	3
6	9	12	88	18	1
7	11	13	78	19	1

and fourteen years; and 72 per cent. were fourteen years and over. Pain, therefore, is an infrequent early symptom in scoliosis.

Onset of the scoliosis was noted between the age of seven and fifteen years in 92 per cent. of the cases (Fig. 1 and Table IV), the most frequent being twelve years of age. Patients presented themselves for treatment within the first year in 55 per cent. of the cases.

An attempt was made to determine the primary curve (Table V) which, in each instance, was taken to be the chief deforming curve, and the one to which other existing curves appeared to be compensatory. There was generally greater rotation and vertebral wedging in the primary area, and it was incompletely correctable on forward or side bending. Right thoracic or thoracolumbar curves were present in 80 per cent. of the cases, while 20 per cent. were left thoracic or thoracolumbar. There were no right lumbar curves and only two were left lumbar.

The extent of the curve (Table VI) varied from a minimum of four vertebrae to a maximum of twelve vertebrae, and 91 per cent. were between six and nine in extent. The vertebra showing the greatest amount of rotation was taken to be the apex of the curve, and this was found to be the ninth thoracic in 24 per cent. of the cases, with the eighth thoracic the next most frequent, 22 per cent., and the first lumbar the third in

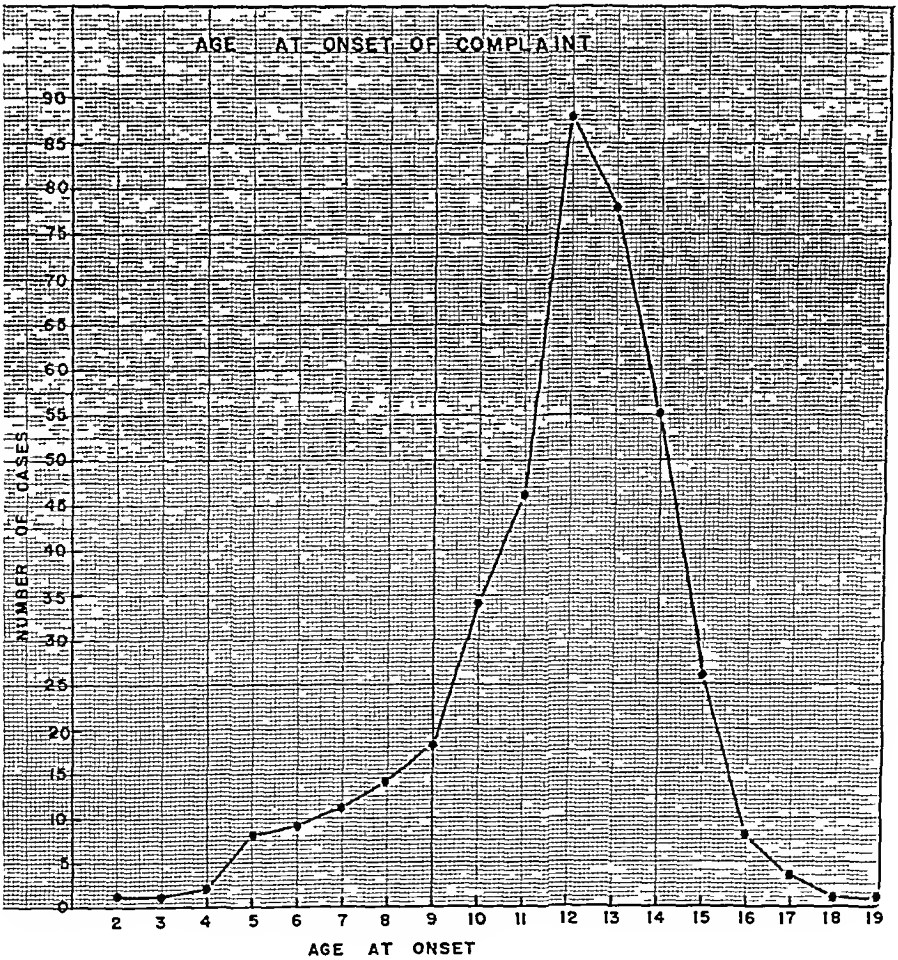

FIG. 1

frequency, 11.5 per cent. (Fig. 2 and Table VII). Mobility of the thoracolumbar junction probably accounts for the increased occurrence at that level.

A measure of the severity of the curve was obtained by determining the end or neutral vertebra on either extreme. These were taken to be the ones showing the least rotation, with the interspace approximately equal on either side. A line was then drawn parallel with the top of the upper-end vertebra and one parallel with the bottom of the lower-end vertebra and a perpendicular erected to each of these lines. The angle of deviation from the normal (180 degrees) was then measured at the intersection of these two perpendicular lines (Fig. 3). These measurements were made on roentgenograms taken with the patient standing and supine when both were available, as an indication of flexibility of the curve. The distribution of the curves is shown in Figure 4. With slight curvatures—0 to 20 degrees—there was very little difference in standing and supine positions. Moderate curves—25 to 40 degrees—showed 5 to 10 degrees difference, while severe curves—45 degrees and over—were fairly rigid and showed but slight increase in standing measurements.

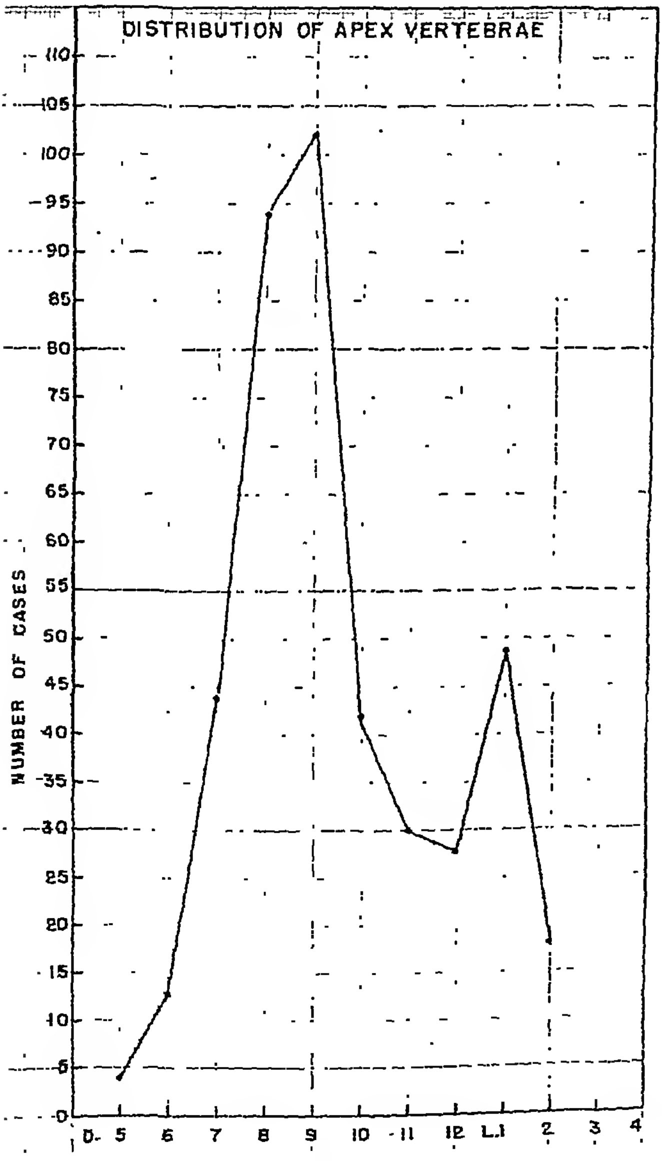

Fig. 2

Distribution of apex vertebra.

Eleven patients in the series measured the same in standing and supine positions, 36 per cent. being patients between eleven and thirteen years and 64 per cent. being patients over fourteen years at start of treatment. This further indicates the tendency for the curve to become fixed in the older group.

A review of the body asymmetry showed the shoulder to be high on the right in 56 per cent., high on the left in 23 per cent., and shoulders level in 21 per cent. Measurements varied from one-quarter to two inches, the average being between a quarter and a half inch (Table VIII). Lateral deviation of the center of the sacrum from a plumb-line dropped from the seventh cervical vertebra was noted. Forty-five per cent. showed no list, 40 per cent. listed to the right, and 15 per cent. to the left. For those with a list the measurements varied from one-fourth to two inches (Table IX), the majority being

TABLE V

PRIMARY CURVE

Location of Curve	No.	Per Cent.	
Right thoracic	230	54.0	79.5
Right thoracolumbar	109	25.5	
Left thoracic	23	5.5	20.0
Left thoracolumbar	61	14.5	
Right lumbar	0	0.0	0.5
Left lumbar	2	0.5	
Total	425	100.0	

one-fourth to one-half inch. The list and high shoulder were generally on the side of the primary convexity, and, along with measurements of standing and sitting height photographs, and roentgenograms, serve to estimate the clinical progress of treatment.

Treatment varied in the different clinics (Table X) according to what the surgeon felt was an acceptable result, considering the amount of treatment necessary to arrive at that goal and the probability of maintaining such a status once it had been attained.

TABLE VI

EXTENT OF CURVE

No. of Vertebrae Involved	No. of Cases	Per Cent.	
4	1	0.25	
5	10	2.5	
6	64	15 0	387 cases, or 91 per cent., were 6 to 9 vertebrae in extent
7	127	30.0	
8	142	33.5	
9	54	12.5	
10	19	4.5	
11	7	1.5	
12	1	0.25	
	425	100.0	

It was generally felt that a mild curve with good compensation and slight body asymmetry was best treated by symmetrical postural exercises under close observation, so as to maintain a certain amount of flexibility and to improve posture. Asymmetrical exercises were carried out in a few clinics to produce mobility and to aid in regaining compensation; and in some instances to favor weaker muscles and reduce the pull of stronger ones, particularly by those who feel that muscle imbalance is a factor in the production of idiopathic scoliosis. Most men agree that postural improvement can be expected from a regimen of exercises, but the curve itself cannot be decreased by this

TABLE VII

APEX OF CURVE

Location	No.	Per Cent.	Location	No.	Per Cent.
Fifth Thoracic	4	1 0	Tenth Thoracic	42	10 0
Sixth Thoracic	13	3 0	Eleventh Thoracic	30	7.0
Seventh Thoracic	44	10.5	Twelfth Thoracic	28	6 5
Eighth Thoracic	94	22.25	First Lumbar	49	11 5
Ninth Thoracic	102	24 0	Second Lumbar	18	4.25
Total				424	100 0

means. Strenuous exercises should be prescribed cautiously, since they may mobilize a rigid curve and allow further collapse.

Some form of support was used during the exercise and observation period, and was felt to be of benefit in many clinics. This generally consisted of a light brace, incorporating a lateral corrective force, such as the turnbuckle brace and the elastic traction brace, or a light plaster or a jacket of cellulose acetate composition.

Of 185 patients originally treated by exercises of all types (Table XI) the curve in 35 per cent. remained unchanged, in 34 per cent. increased moderately (5 degrees to 15 degrees) and in 27 per cent. increased markedly (20 degrees and over). An improvement of 5 degrees was shown in 4 per cent.; this may be within the limits of error of measure-

Fig. 3

Illustration of method of measurement of the curvature.

TABLE VIII
SHOULDER LEVEL
(405 Cases)*

Difference in Level (*Inches*)	High Shoulder on Right		High Shoulder on Left	
	No. of Cases	Per Cent.	No. of Cases	Per Cent.
¼	103	25 5	46	11.25
½	107	26 5	35	8.50
¾	8	2.0	1	0.25
1	9	2.25	8	2.0
1½	1	0.25	1	0.25
2	0	0.0	1	0.25
Total	228	56.5	92	22.5

* No difference in level in 85 cases or 21.0 per cent.

TABLE IX
LIST
(395 Cases)

	Per Cent.		Per Cent.
No list	45	Left ¼ inch	5
Right ¼ inch	12	Left ½ inch	6
Right ½ inch	16	Left ¾ inch	1
Right ¾ inch	4	Left 1 inch	2
Right 1 inch	6	Left 1¼ inches	0 5
Right 1½ inches	1	Left 1½ inches	0 5
Right 2 inches	0 5	Left 2 inches	0 5

Total list to right	39 5 per cent.
Total list to left	15 5 per cent.
No list	45.0 per cent.

ment. The curve in one patient apparently improved 10 degrees. It is interesting to note that 53 per cent. of those having symmetrical postural exercises showed an increase of curvature, while 75 per cent. of those having asymmetrical exercises showed increase in curvature, possibly due to the more vigorous type of exercises.

Correction, followed by support, without subsequent fusion is carried out in selected cases in three clinics, while correction and fusion is the method of choice for progressive cases within the growth period according to the majority. Fusion without correction has generally been limited to long-standing cases in patients with symptoms of back strain, or when conditions would not permit the prolonged hospitalization required for correction.

Correction has been accomplished by means of windowed casts for gradual wedging

TABLE X
TYPE OF TREATMENT CARRIED OUT IN VARIOUS CLINICS

	Yes	*No*
Symmetrical postural exercises	16	2
Asymmetrical mobilizing exercises for compensation	7	11
Brace or plaster support during exercise observation period	12	6
Correction followed by support without fusion in progressing cases	3	15
Correction and fusion in progressing or badly deforming cases	16	2
Fusion without correction in progressing or symptomatic cases	2	16

TABLE XI

EXERCISES AND EFFECT ON CURVES (IN PERCENTAGES)

Effect on Curves	Average for All Curves (185 Cases)	Symmetrical Exercises			Asymmetrical Exercises		
		Mild Curves 0–20° (26 Cases)	Moderate Curves 25–40° (55 Cases)	Severe Curves Over 40° (39 Cases)	Mild Curves 0–20° (10 Cases)	Moderate Curves 25–40° (25 Cases)	Severe Curves Over 40° (30 Cases)
Unchanged	35	30	49	42	10	28	21
Increased:							
(5–15°)	34	54	23	39	50	40	50
(20° and over)	27	16	21	17	30	32	26
Improved (5°)	4	0	7	2	10	0	3
Total	100	100	100	100	100	100	100

with felt pads, by the Cook cast which incorporates lateral traction bands through a window in the plaster, by horizontal suspension in a fishnet hammock during plaster application, and by the Risser turnbuckle jacket (Table XII). The latter was the most popular method of correction.

The Risser jacket was used to correct the curve prior to fusion in 149 patients (Table XIII). In those with mild curvature—0 to 20 degrees—an average of 71 per cent. correction was obtained. With moderate curves—25 to 40 degrees—an average of 72 per cent. correction was obtained (fifty-one cases), and in severe cases—45 degrees and over—53 per cent. correction was the average (eighty-eight cases). The percentage of correction in the end result in these same groups averaged 33 per cent. in the mild group, 25 per cent. in the moderate group, and 24 per cent. in the severe group. Patients corrected by other means are not numerous enough for individual percentages and will therefore be considered as one group. There were thirty-one such cases, and, including all degrees of curvature encountered, an average of 42 per cent. correction immediately postoperative was obtained, and the percentage of correction in the end result amounted to 15.

TABLE XII

METHOD OF GAINING CORRECTION

Apparatus	Number of Clinics Using the Method
Risser turnbuckle jacket	13
Fishnet horizontal suspension jacket	2
Bent jacket, with window and pressure pads	1
Bent jacket, with window for lateral traction bands	1
Head, pelvic, and lateral traction	1

In the entire group of 180 patients corrected and fused, complete correction was gained in ten, or 5.5 per cent. There was complete loss of correction in fifty-three patients, or 30 per cent., and no loss of correction in fifteen, or 8 per cent.

Correction without fusion, carried out in thirty-two patients, resulted in a total loss of correction, after discontinuing support, in 72 per cent. of the cases (Table XIV).

Some clinical improvement of the rotation deformity occurred following correction with the Risser jacket in 48 per cent. of the 126 patients on whom these data were

TABLE XIII

AVERAGE OF PERCENTAGE OF CORRECTION OF EACH CURVE

Type of Curve	Risser Jacket			Other Types		
	No.	Immediately Post-operative (*Per Cent.*)	End Result (*Per Cent.*)	No.	Immediately Post-operative (*Per Cent.*)	End Result (*Per Cent.*)
Mild (up to 20 degrees)	10	71	33	1	85	45
Moderate (25 to 40 degrees)	51	72	25	8	40	15
Severe (45 degrees and over)	88	53	24	22	41	13
Total	149	61	25	31	42	15

TABLE XIV

CORRECTION WITHOUT FUSION

(32 Cases)

72 per cent. lost all of correction gained
10 per cent. maintained 5 degrees of correction
12 per cent. maintained 10 degrees of correction
6 per cent. maintained 15 degrees of correction

100 per cent.

TABLE XV

COMPARISON OF ROTATION BEFORE AND AFTER TREATMENT WITH RISSER JACKET IN 126 CASES WITH KNOWN RESULTS

61 cases, or 48 per cent., showed less rotation
53 cases, or 42 per cent., showed same rotation
12 cases, or 10 per cent., showed more rotation

126 100 per cent.

available. The deformity apparently changed very little in 42 per cent., and was more noticeable in 10 per cent. (Table XV).

The most frequent fusion employed additional bone, generally from the tibia. A classical Hibbs fusion was done in eighty-three patients, and pseudarthrosis resulted in twenty-four instances or 29 per cent.; a Hibbs fusion plus a graft in fifty-two patients resulted in seventeen pseudarthroses or 33 per cent.; the Albee fusion in four instances, with 25 per cent. pseudarthrosis; a McKenzie Forbes type in seventy-four instances, with seventeen pseudarthroses or 23 per cent.; and one strut graft was done, resulting in pseudarthrosis. Incidence of pseudarthrosis for the entire group was 28 per cent. (Table XVI). These percentages represent only a small group for each type of fusion, and are subject to the varying technique and subsequent care of many clinics.

There were 180 patients who were corrected and fused, with resulting pseudarthrosis in fifty-four instances. Average loss of correction in the pseudarthrosis group was 21.2 degrees, and in the non-pseudarthrosis group 15.1 degrees. Apparently, while pseudarthrosis is a contributory factor in the loss of correction, it is not the chief cause. Early detection and repair of the pseudarthrosis, however, will save some loss of correction.

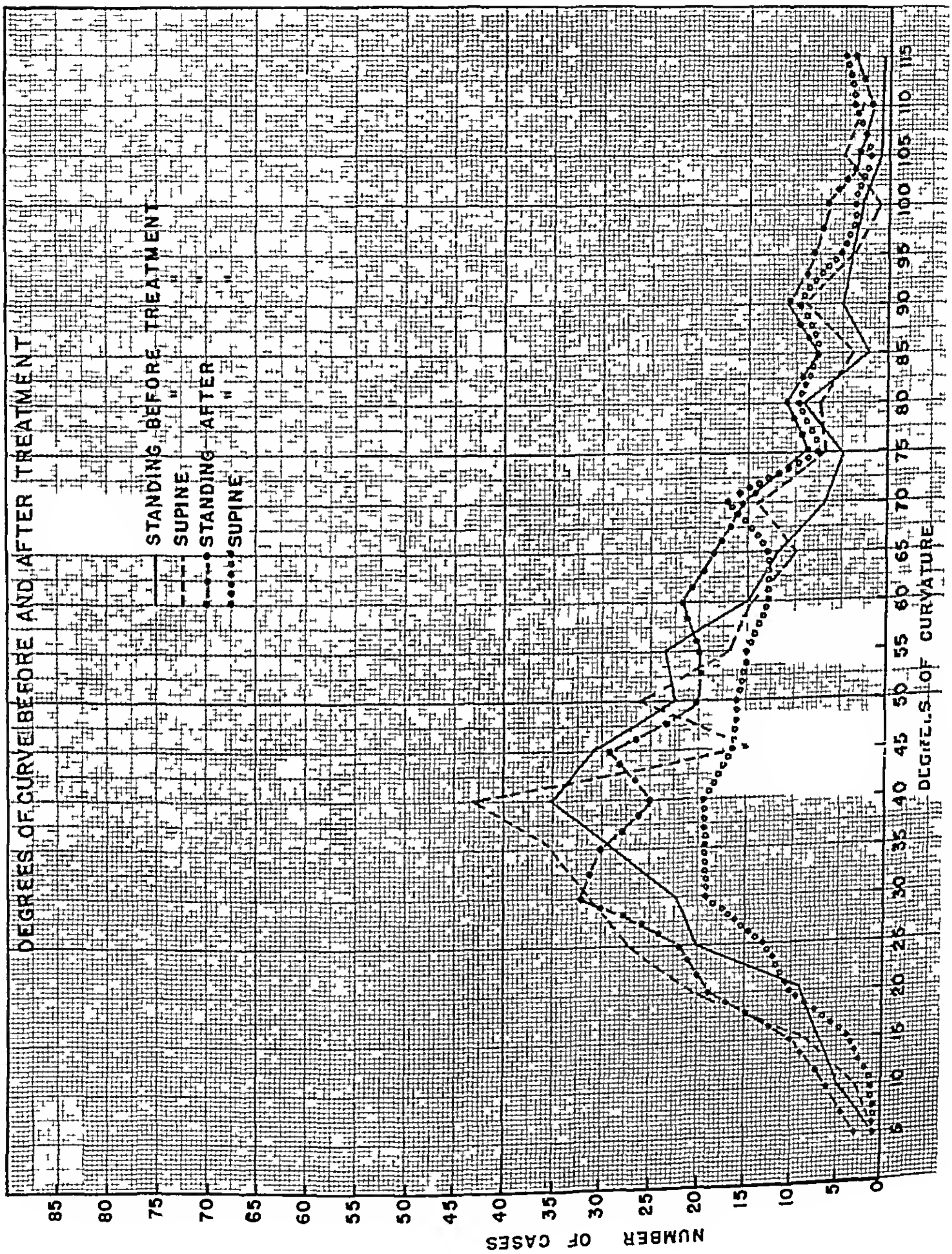

Fig 4

Curvature measurements before treatment and at end result

TABLE XX

AGE AT START OF TREATMENT AND END RESULTS (IN PERCENTAGES)

Age (Years)	Entire Series						Risser Series					
	No.	Excellent	Good	Fair	Poor	Total	No.	Excellent	Good	Fair	Poor	Total
Two to ten	26	0	19	27	54	100	9	0	0	55	45	100
Eleven	22	4.5	22.5	32	41	100	17	6	10	40	44	100
Twelve	54	4	23	30	43	100	16	6	44	33	17	100
Thirteen	98	2	22.5	52	23.5	100	40	6	37	35	22	100
Fourteen	95	7	35	43	15	100	30	10	30	40	20	100
Fifteen	55	0	36.5	51	12.5	100	12	0	50	33	17	100
Sixteen	34	0	30	47	23	100	9	0	20	50	30	100
Seventeen and over	41	0	24.5	61	14.5	100	16	0	25	50	25	100
Total average	425	3	28	45	24	100	149	5	32	42	21	100

TABLE XXI

TREATMENT AND CLINICAL RESULTS

Clinical Appearance of Back	Risser Jacket and Fusion (132 Cases) (*Per Cent.*)	Risser Jacket without Fusion (16 Cases) (*Per Cent.*)	Other Types of Correction and Fusion (25 Cases) (*Per Cent.*)	Other Types of Correction without Fusion (25 Cases) (*Per Cent.*)	Traction and Fusion (10 Cases) (*Per Cent.*)	Observation Only (18 Cases) (*Per Cent.*)	Exercises (152 Cases) (*Per Cent.*)
Markedly improved	24	0	12	0	0	0	0
Moderately improved	43	0	28	0	40	33	5
Unchanged	22	50	32	48	40	55	59
Slightly worse	9	37	20	32	10	12	20
Much worse	2	13	8	20	10	0	16
Total	100	100	100	100	100	100	100

NOTE: Some cases are listed in more than one group owing to change of treatment.

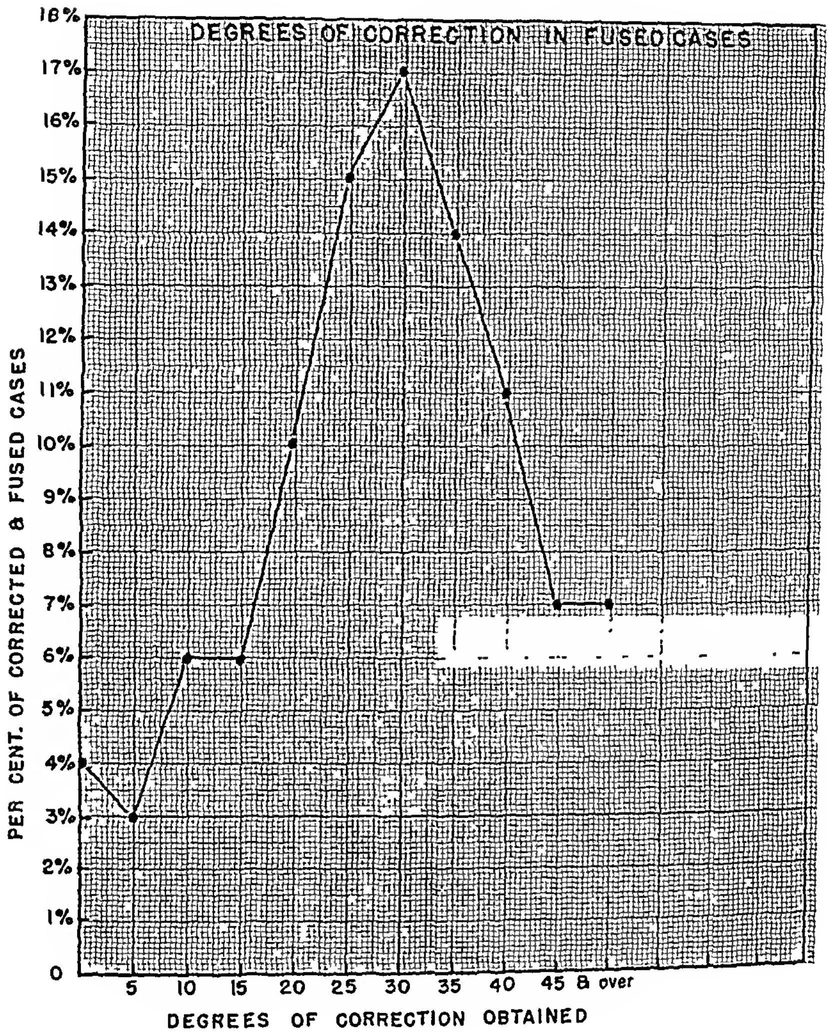

FIG. 5

Improvement of the shoulder level occurred in 50 per cent. of the patients, remained the same in 25 per cent., was worse in 12 per cent., the shoulders were level in 13 per cent. Hip prominence was unchanged in 67.5 per cent., improved in 22 per cent., worse in 8 per cent., and equal in 2.5 per cent.

According to statements by the patients in 252 instances, 72 per cent. felt they were improved, 21 per cent. were unchanged, and 7 per cent. were worse. Relatively few more patients complained of backache at end result than on admission, there being 14.5 per cent. in the former group and 8 per cent. in the latter. Eighty-five per cent. had no complaint of pain. Activities were normal in 85 per cent., slightly limited in 14.5 per cent., and considerably limited in 0.5 per cent. Therefore, in scoliosis treatment the chief concern is for the cosmetic result. The most persistent complaint, even after correction and fusion, is that of the posterior rib prominence, which seems to be more or less permanent.

It is a difficult matter to give an end-result rating to a condition such as this, since the scoliosis itself is rarely cured, and opinions as to what can be and should be achieved at end result are so varied. However, an attempt has been made to form a composite picture considering the physician's aim in treatment, the inconvenience and time necessary to arrive at that goal, and finally whether the condition had been improved, remained stationary, or had progressed. Since 92 per cent. of the complaints were of cosmetic deformity, this must also carry the most weight in end-result rating. Bearing the

points in mind, excellent rating was reserved for those in whom residual deformity was slight and roentgenograms revealed the curve to be of minor degree. Good rating included those patients who had a moderate curvature, but were well balanced and concealed the deformity satisfactorily. Results were rated fair when the curvature was moderately severe and the patient displayed obvious cosmetic defects, while a poor rating was given for those with severe curvature and marked body asymmetry.

Of 425 cases reviewed, twelve, or 3 per cent., were rated excellent; 119, or 28 per cent., good; 191, or 45 per cent., fair; and 103, or 24 per cent., poor. Results in patients with scoliosis appearing before the age of ten years were rather poor, even though they came for treatment early (Table XX). Also, the results in patients in the upper-age group at the start of treatment were not as good as those in the group of twelve-to-fifteen-years. If the clinical appearance of the back at end result is compared with what it was when the patient was first seen (Table XXI), it will be noted that the best cosmetic results were obtained in the group treated by correction in the Risser jacket and spine fusion.

SUMMARY

Four hundred and twenty-five cases of idiopathic scoliosis have been reviewed from an end-result standpoint. Cosmetic deformity is the chief complaint, the patients generally having no other symptoms. It is a disease appearing most frequently at the time of puberty, and predominating in girls about four to one. Curvature is to the right in 80 per cent. of the patients, most commonly in the mid-thoracic region.

All types of treatment were encountered in the series including observation only, symmetrical and asymmetrical exercises, supports, correction, and fusion, and combinations of all types. Fifty per cent. (214) of the patients reviewed had fusions done either immediately or after conservative treatment had been abandoned in favor of surgery. Correction was by means of the turnbuckle jacket in 80 per cent. of those corrected and fused. The average percentage of correction obtained was 65 and the average percentage of correction at end result was 27. Complete correction was gained in only 5.5 per cent. of the corrected cases, all of the correction was maintained in 8 per cent., and there was complete loss of correction in 29 per cent.

Additional bone grafts were used in 60 per cent. of the patients operated upon, and the incidence of pseudarthrosis for the entire operative group amounted to 28 per cent. Recumbency following fusion for three months was carried out with 47 per cent. of the patients.

The results in 69 per cent. of the cases at end result were rated fair or poor, and 31 per cent. good or excellent.

CONCLUSIONS

1. Practically none of the patients with scoliosis are cured, if correction of lateral deviation is a criterion.
2. In approximately 60 per cent. of those treated by exercises the deformity increased and in 40 per cent. it remained unchanged.
3. Correction without fusion resulted in complete loss of correction after support was discontinued, in the majority of instances.
4. Correction by the turnbuckle jacket and subsequent fusion has yielded better results in this series than have other types of treatment.

A. R. Shands, Jr., M.D., *Chairman*
Joseph S. Barr, M.D.
Paul C. Colonna, M.D.
Lawrence Noall, M.D., *Research Fellow of The Nemours Foundation*

News Notes

The Annual Meeting of **The American Academy of Orthopaedic Surgeons** will be held January 11 to January 15, 1942, in Washington, D. C. Headquarters will be at the Mayflower Hotel. Dr. J. E. M. Thomson, of Lincoln, Nebraska, is Chairman of the Program Committee. A group of refresher courses is being planned in conjunction with the regular program.

Dr. Clarence H. Snyder announces the association with him of Dr. Harvey M. Andre in the practice of orthopaedic surgery and the treatment of fractures. Their office is located at 201-202 Medical Arts Building, Grand Rapids, Michigan.

Dr. Roger Anderson has announced that Dr. Ernest Burgess is now associated with him in the practice of orthopaedic surgery, at 1307-1319 Medical Building, Seattle, Washington.

The Annual Meeting of **The Orthopaedic Guild** will be held in Detroit, October 24 and 25. Dr. C. L. Mitchell, of Henry Ford Hospital, will be Chairman of the meeting.

The Annual Clinical Congress of the **American College of Surgeons** will be held in Boston, November 3 to 7, 1941.

Under the auspices of the American Association of Industrial Physicians and Surgeons, the **American Conference on Industrial Health** will hold its Second Annual Meeting on November 5 and 6, 1941, at Chicago Towers, Chicago.

Duke University School of Medicine and **Duke Hospital** announce a Symposium on "Problems of Civil and Military Emergencies" to be held on October 16, 17, and 18, in the Page Auditorium, West Duke Campus, Durham, North Carolina. The program includes an outstanding group of speakers. Dr. Lenox D. Baker is Chairman of the Symposium Committee.

The Association of Military Surgeons of the United States will meet at the Brown Hotel, Louisville, Kentucky, October 29 to November 1. All members of the medical profession are invited, and it is hoped especially that many members of the Medical Defense Committees will attend. Present policies and activities in the medical departments of the United States Army and Navy will be the principal topics of discussion. The session will conclude with a mass review of Military Medicine and an inspection of Fort Knox.

THE BRITISH ORTHOPAEDIC ASSOCIATION

The Summer Meeting of The British Orthopaedic Association, under the presidency of Prof. T. P. McMurray, was held at the Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, on August 9, 1941. A large number of members attended, and among the guests were representatives of the American Hospital in Britain.

The scientific program consisted of a clinical demonstration and the presentation of several short papers, of which the following is a résumé:

Current Literature

The Intervertebral Disc with Special Reference to Rupture of the Annulus Fibrosus with Herniation of the Nucleus Pulposus. F. Keith Bradford, M.D., and R. Glen Spurling, M.D. Springfield, Illinois, and Baltimore, Maryland, Charles C. Thomas, 1941. $4.00.

In this little book the authors have, on the whole, concisely and excellently portrayed the present status of rupture of the intervertebral disc or, as termed in their book, "rupture of the annulus fibrosus with herniation of the nucleus pulposus".

The embryology, anatomy and physiology, and pathology of the intervertebral disc are first described and illustrated. The authors emphasize the fact that, because of the constant stress and strain brought to bear on the intervertebral discs, any incipient pathology becomes exaggerated without the occurrence of a single severe traumatic episode.

Next, the clinical and roentgenographic investigation of patients with low-back and sciatic pain, and the clinical findings in lumbar herniations of the nucleus pulposus are discussed. The authors state that back pain usually follows injury much more directly than does sciatic pain, and the latter may be mild or absent for several days or weeks following injury. In the large group of patients giving no history of injury, many have occupations which produce constant wear and tear on the lumbosacral spine. The authors feel that this must be considered as important an etiological factor as frank trauma. The Laségue test is discussed, and a more refined test, called "the sciatic-nerve-stretching test", is suggested. The authors believe that lumbar puncture should be performed on every patient in whom the clinical diagnosis of herniated nucleus pulposus is made. They advise removal of the spinal fluid in three portions of three cubic centimeters each. They feel that roentgenographic examination is more important in excluding other lesions than in making directly the diagnosis of ruptured disc. Lipiodol is considered to be a relatively benign substance, administered in the spinal subarachnoid space, and should be used when the localization of a lesion is in doubt. While there is probably no denying histopathological changes in the leptomeninges at least temporarily after using lipiodol, there is probably no permanent damage to the spinal cord and nerve, in the authors' opinion. The authors have nothing to say about the recent practice of removing lipiodol by lumbar puncture in all cases, whether or not operation is contemplated. This practice probably represents an important advance in the handling of these cases. Also, while the use of air for contrast myelography is mentioned, it is not described in detail, and this is regrettable. Rupture of the intervertebral disc is now considered to be the most common single cause of severe persistent or intermittent sciatic pain. The distribution of pain is said not to be of much help in localizing the lesion. Abnormal sensation—that is, paraesthesia in the form of burning, tingling, etc.—is held to be important.

In the section on treatment and results, the authors emphasize the fact that disability resulting from low-back pain, due to disease of the intervertebral disc, without root pain, is almost always an orthopaedic problem. If the pain is intractable to orthopaedic procedures, however, contrast myelography should be considered. The acute case of low-back pain with sciatic disability should have the benefit of conservative procedures also, before surgical measures are considered. The surgical technique is very thoroughly discussed and should be of great value to those who are occupied with the treatment of this problem. In the postoperative treatment, the authors advise recumbency for from two to three weeks. If the annulus fibrosus has been extensively lacerated, the patient is fitted with a low-back brace before discharge.

The authors next discuss the history and findings in injury to the nucleus pulposus

and allied conditions, such as sacro-iliac and lumbosacral injury, narrowing of the intervertebral foramina, the facet syndrome, spondylolisthesis, contracture of the fascia lata, hypertrophy of the ligamentum flavum, etc.

In their chapter on cervical herniations of the nucleus pulposus, the authors admit that in their advanced cases at least the recoveries are very poor, although exploration should always be made. Thoracic herniations are the least likely to occur because the discs are thinner, the volume of the nucleus is less, and movements are much more limited than in the cervical or lumbar spine.

Thirteen cases are reported. On the whole, these cases do not represent the average but rather the unusual type. Lipiodol was not used in all of them, and the roentgenograms are not representative of the ordinary case of ruptured disc. It might have been preferable to give typical cases with typical roentgenograms, although the unusual ones admittedly are of real interest since, as time goes on, one is confronted with an increasing number of atypical cases which must be diagnosed and properly treated. A very complete bibliography is appended.

The book is an excellent one and gives the reader a fundamental understanding of the subject.

Études sur les amputations et désarticulations des membres (Studies on the Amputations and Disarticulations of the Extremities). P. Huard. Paris, Masson & Cie, and Hanoi, Indo-China (G. Taupin & Cie), 1940.

It is unfortunate, as the author points out, that the subject of amputations, which had come to assume a relatively minor place in surgery, has been, by the exigencies of recent war, brought to a position of major importance. In recent years relatively few volumes have been devoted exclusively to this subject, and the present work is an attempt to fill this gap.

The book is divided into three large divisions, the first of which is concerned with generalizations on the physiopathology of amputation stumps, and on general indications for amputation, with specific consideration of amputation for special problems. In general, the author is of the Duval school, and inclines to the principle of the elliptical incision, with the longer portion of the ellipse placed over the flexor surface of the extremity to be amputated.

The second portion of the work is dedicated to a consideration of the various amputations and disarticulations of the superior extremities. The third portion is devoted to a consideration of the problem presented by amputations and disarticulations of the lower extremities. All of the standard operative interventions are discussed and each technique is described in considerable detail. However, this is not just a compilation of operative techniques. On the contrary, it is an exhaustive and intelligent survey of the problem, not only from the technical and surgical point of view, but more particularly from the patient's point of view. The question of reeducation and psychic readaptation of the patient to the altered conditions under which he must continue his activities is discussed in a most understanding manner.

Particular attention is paid to the type of prosthesis which must be applied to the patient after operation. Emphasis is laid upon the opinion that the amputation must be adapted to the mechanical efficiency of the prosthesis, rather than the prosthesis adapted to the operation. The author always bears in mind and stresses the fact that this is not an academic problem, but rather is one of intensely practical importance. The sites of election for amputation, in regard to both the level of amputation and the application of the prosthesis, are emphasized.

A short chapter on the technique of lumbar ganglionectomy is appended. Numerous details of anatomical, surgical, and functional significance, culled from the wide experience of the author, are constantly discussed at appropriate length.

The work is adequately illustrated, with somewhat less than 300 plates, half-tones, and line drawings, which show the effect of war-time economy. There is an extensive

index of authors, and an elaborate bibliography, which amply indicates not only the wide learning of the author, but also the exhaustive nature of the work.

INFANTILE PARALYSIS—ANTERIOR POLIOMYELITIS. Philip Lewin, M.D., F.A.C.S. Philadelphia, W. B. Saunders Co., 1941. $6.00.

This new book attempts to give the whole story of infantile paralysis, and succeeds very well. The chapters on Etiology, Epidemiology, and Predisposing Factors are ably presented in a simple concise style by Dr. Howard J. Shaugnessy. An excellent chapter on Pathogenesis and Pathology is written by Dr. Sidney O. Levinson. The remainder of the book appears under the author's name.

No phase of the disease or of its treatment is omitted. As may be expected in such a text, many controversial subjects are presented. As an example, the use of human convalescent serum in the early treatment of the disease is emphasized, whereas in the opinion of many other authorities, convalescent serum is no longer considered to have any protective or curative effect. The various methods of applying physical therapy, including underwater treatment, are ably presented. However, the real value of physical therapy during the convalescent stage of infantile paralysis is now being questioned, and insufficient emphasis is given this most important discussion.

Many, if not most, of the corrective operative procedures utilized in the care of anterior poliomyelitis are presented. The subject is well handled for this type of book—written apparently for *the student, the practitioner*, and *the specialist*—although the indications and choice of procedures are not always clear.

In the Appendix of the book is included much valuable information relative to the Public Health, Nursing, and Educational problems.

The book may be highly recommended as a reference text for those interested in the treatment of infantile paralysis. The subject matter is presented in encyclopaedic form, leaving the actual choice of method or procedure to the judgment of the reader.

BODY MECHANICS IN HEALTH AND DISEASE. Joel E. Goldthwait, M.D.; Lloyd T. Brown, M.D.; Loring T. Swaim, M.D.; and John G. Kuhns, M.D. With a Chapter on the Heart and Circulation as Related to Body Mechanics by William J. Kerr, M.D. Ed. 3. Philadelphia, J. B. Lippincott Co., 1941. $5.00.

In the first edition, the authors called attention to the fact that the chronically ill were given but scant attention, and that most of those acutely ill, presenting more interesting and solvable problems, were given the most attention. Opportunity was taken in this third edition to change the title to "Body Mechanics in Health and Disease". The authors say: "The early recognition and proper treatment of conditions which inevitably lead to disease are the most important functions of modern medicine", and also, "most of the chronic diseases are associated with the wrong use of the body which must have begun in childhood or early adult life". They have added, therefore, a chapter on "Developmental Deformities". An interesting chapter has been contributed also by William J. Kerr of California concerning the heart and circulation as related to body mechanics.

This book is filled with generalizations and what might be called loose statements, which would not withstand close scrutiny. For example, it is stated that chronic valvular diseases of the heart are very common and one of the commonest causes of death. Today it is well known that chronic hypertensive diseases of the heart and angina pectoris are far more common causes of death than valvular disease. The statement is also made that electrocardiography, in determining the amount of damage to the cardiac muscle, has no direct value on prognosis. This statement can very rightfully be challenged. For example, in complete heart block and in cases where there has been an infarct, the electrocardiogram does have a very direct diagnostic value and, therefore, prognostic value, because, while the exact length of life cannot be predicted, it is well known that these patients do not live very long. However, the book presents a point

of view that is valuable, and it should be interesting to any practitioner. The rank and file of the profession treat their patients as individuals, and they often do not classify the individual as to type based upon anatomical and physiological background. Therefore, the discussion of the three different types of individuals which the authors call the normal—that is, the intermediate, the slender, and the stocky—is interesting. They, themselves, acknowledge the dangers of too close an adherence to this generalization.

They make the statements that the slender and stocky types can be recognized in all age periods, but in a pure form are almost as rare as the intermediate type, although the proportion of individuals of slender type is increasing, and that mixtures and gradations of types are common. These deductions were apparently based on the statistics of Dear in a study of a large number of officers in the United States Army.

The chapter on "Angina Pectoris and Postural Emphysema Related to Obesity" by Kerr presents an interesting point of view, and one which very evidently fits in with the theories of the orthopaedic surgeons writing this book. However, it is to be noted that other observers and workers in cardiology have not been so enthusiastic about the treatment with the Kerr-Lagin belt as are the authors.

In the various chapters are included case reports which are interesting. However, in the chapters on diseases of the nervous system, the authors state they do not wish to assert "the correction of body mechanics will cure all chronic nervous diseases", which would intimate that they would feel they can cure some. The case reports on multiple sclerosis are very interesting, and some interesting recoveries were made. It probably was not the intention of the authors to claim that the correction of poor posture, et cetera, caused recovery, but they do say that "while the exact cause of this condition is not perfectly understood, in many cases when the faulty body mechanics with the associated physiologic disturbances is corrected, health is restored". This is a broad statement, and there is not much to back it up. No series of cases is presented and the data presented are sketchy.

The chapter on chronic arthritis is very good, as would be expected.

The chapter on the foot is too short to be of much value, and here, again, generalization and broad statements weaken the presentation.

The final chapter on "Public Health Aspects of Body Mechanics" savors of the crusader. Nevertheless, there is much that is sound in it, and all orthopaedic surgeons would agree that much of the teaching suggested should be carried out in our schools, colleges, et cetera.

El pie talo poliomielítico y su tratamiento (estudio de 170 casos) [The Club-Foot of Poliomyelitis and Its Treatment (A Study of 170 Cases)]. Dr. Vicente Sanchis Olmos. Madrid, Espasa-Calipe, S. A., 1940. 10 pesetas.

This monograph was written and ready for publication in 1936, but the Spanish War prevented its publication until 1940. It deals with the treatment of the paralytic club-foot. The first 114 of the 142 pages consist of a general discussion of the subject, which is well organized and well presented. The last twenty-eight pages contain an outline of the clinical histories of the 170 cases. The clinical histories are presented in very short abstract form, and are outlined in charts which show the paralyzed muscles, type of deformity, treatment, and end result. The author states that these cases are presented so that any one interested may review the material, himself.

The material in the monograph is very well organized, and the first and longest section, which deals with the discussion of the subject in general, is divided into chapters. The first chapter deals with the normal architecture and physiology of the foot, and goes into the anatomy in some detail. The second chapter deals with the abnormal anatomy and physiology, and here the mechanism of change following poliomyelitis is brought out. Diagrams are presented, together with roentgenograms and photographs of patients. The method in which the deformities develop is gone into in some detail. The cases in the author's series are tabulated in a chart showing which type of deformity is the

most common. The third chapter deals with what the author calls generalities. He states that considerable time should be allowed to elapse between the occurrence of the paralysis and the surgical treatment. Another factor which enters into the treatment is the age of the patient, and no patient should be treated under the age of six years. The fourth chapter deals with what the author calls orthopaedic treatment of paralytic club-foot, and it is somewhat surprising to realize that the word orthopaedic in the sense in which the author is employing it means conservative or non-operative treatment. The last chapter deals with the surgical treatment of these feet, and is divided into categories according to the type of treatment used. Tendon transplants are employed rather commonly in his series of cases. An operation which is not often used in this country, tenodesis, is referred to and employed frequently. Bone-block operations are used very often, and the types employed are described. A frequent one of these is the anterior block of the talus, in which a piece of bone is placed in a wedge in the anterior aspect of this bone. This operation is rather commonly combined with a subastragalar arthrodesis, and the author feels that the results are quite good. He mentions the other types of arthrodesis in the foot. The triple arthrodesis, which is used so much in the United States, is used only seven times in his series of cases, while simple subastragalar arthrodesis was used twenty-one times, and numerous other types of arthrodesing operations were used rather frequently. The results of this type of surgery are analyzed by the author.

The monograph as a whole represents a very careful study and analysis of the case studies. An American reader would find very much of interest, and quite a good deal with which he would probably not agree, but at the same time he might learn a good deal about unfamiliar operative procedures. The book is well illustrated with photographs, roentgenograms, and drawings.

THE MEDICAL ANNUAL. A YEAR BOOK OF TREATMENT AND PRACTITIONER'S INDEX. H. Letheby Tidy, M.A., M.D. (Oxon.), F.R.C.P., and A. Rendle Short, M.D., B.S., B.Sc., F.R.C.S., Editors. Bristol, John Wright & Sons, Ltd., 1941.

The 1941 edition of this British medical yearbook marks the fifty-ninth year of its publication. Few, if any, of the yearly editions which have preceded the present issue have been produced under conditions more difficult both for the publishers and contributors. In spite of this fact, practically the same contributors have carried on under wartime conditions to produce an Annual easily the equal of its more recent predecessors.

The book consists of 444 pages of text which covers innumerable subjects of interest to a general practitioner, illustrated with thirty-nine plates and eighty-seven figures. In addition, there are seventy-two pages of the Practitioner's Index which covers recent pharmaceutical and dietetic preparations, medical and surgical appliances, etc.

The references to foreign literature, as might be expected, are less numerous, as journals, especially those from the European continent, have not been reaching England.

Although there is but little material actually relating to war surgery, there are excellent chapters dealing with burns and blood transfusion. For the practitioner who desires a precise reference book which deals with most of the conditions he might encounter, the 1941 Medical Annual will prove of great value.

INFANTILE PARALYSIS. A Symposium delivered at Vanderbilt University, April 1941. New York, The National Foundation for Infantile Paralysis, Inc., 1941. $1.25.

This book contains the series of six lectures on anterior poliomyelitis which were given at Vanderbilt University in April 1941. The object was to present, in as concise a form as possible, a statement of much of the present knowledge on the subject, to record new opinions resulting from research and study, and to correct many of the older theories which have held sway, sometimes because they have been accepted by reason of the lack of critical investigation or the necessary knowledge.

The larger part of the volume is devoted to the discussion of the methods and the results of laboratory study, but it includes the consideration of the etiology and the epidemiology, and there is also a chapter on the general treatment, particularly the orthopaedic treatment, of this disease and its sequelae. The work is covered by the following subjects:

"History of Poliomyelitis up to the Present Time"
"The Etiology of Poliomyelitis"
"Immunological and Serological Phenomena in Poliomyelitis"
"The Pathology and Pathogenesis of Poliomyelitis"
"The Epidemiology of Poliomyelitis"
"Treatment and Rehabilitation of the Poliomyelitic Patient".

To those who are interested in a statement of much of the recent work by many scientific observers, which indicates how far the widespread investigation and study have advanced our knowledge, this volume will be found most satisfactory.

THEORY OF OCCUPATIONAL THERAPY FOR STUDENTS AND NURSES. Norah A. Haworth, M.A. (Cantab.), M.R.C.S., L.R.C.P., D.P.M., and E. Mary MacDonald. Baltimore, The Williams & Wilkins Company, 1941. $2.00.

This book is probably intended to be descriptive rather than instructive, for occupational therapy has advanced so far, and has increased its field of application and developed the means and methods of application to such an extent, that a book of this size could not attempt more. There is an interesting history of the beginning and of the growth of occupational therapy, which dates it back rather farther than is usually considered. A discussion is also included of the mental and physical conditions in which this therapy finds its special use. However, the advisability of incorporating in a book of this kind the discussion of the pathology of these diseases, particularly the mental diseases, might be questioned. The products of occupational therapy, which are available in the treatment of those conditions in which it is adapted, the equipment which is used in the schools for the training of the pupils, as well as the materials to be selected in dealing with the patients, are very well illustrated, and suggestions are given as to the choice of application to these same pathological conditions. The reader is given an excellent idea of the practical use of this therapy, also of its development and the state to which it has progressed up to this time, and the very wide acceptance which has been accorded to this method of treatment.

THE MARCH OF MEDICINE. New York Academy of Medicine Lectures to the Laity, 1940. New York, Columbia University Press, 1941. $2.00.

The present-day custom of enlightening the public with respect to matters of medical and public-health interest deserves to be encouraged. The advantages of doing this accrue to the medical profession as well as to the laity. The New York Academy of Medicine is to be commended for giving a wider publicity to this group of lectures through their publication in book form. Each one of them gives in a concise and non-technical form the high lights of the topics discussed. They are interesting to a medical reader, and informative to the uninitiated. It would be difficult to single out any one as outstanding. They are all extremely well done. It seemed a little unfortunate that Hans Zinsser's contribution to our knowledge of the viruses was not even mentioned. To this reviewer the lectures on "The Inheritance of Mental Disease", "The Story of Our Knowledge of the Blood", and "The Ascent from Bedlam" were the most interesting. This volume should find a place in every medical library, public and private.

ÜBER DIE BEHANDLUNGSERGEBNISSE BEI SCHWEREREN FERSENBEINBRÜCHEN (The Results of Treatment in Serious Fractures of the Calcaneum). Albert Ahlberg. *Acta Chirurgica Scandinavica*, LXXXIV, 187, 1940.

Of 122 fractures of the calcaneum, which the writer followed for over five years, 60 per cent., or ninety-five fractures in eighty-eight patients, were of the severe type, grouped

by Böhler as V to VIII. The author noted that in none of these cases was there anatomical restoration of the fragments with any of the various types of treatment, and that in only six was there normal motion of the subastragalar joint. The degree of mobility seemed to be unrelated to the accuracy of anatomical restoration of the joint surfaces: and joint changes seemed to be dependent on the nature of the fracture, irrespective of the method of treatment. The writer agrees with the opinions which he finds in the literature,—that subastragalar arthrodesis should be performed after four to five months, if symptoms persist.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

FRACTURES OF APPARENTLY HEALTHY BONE WITHOUT UNQUESTIONABLY TRUE ELEMENT OF ACCIDENT. Abraham Troell, Gunnar Lauritzen, and Arnold Möller. *Acta Chirurgica Scandinavica*, LXXXIV, 226, 1940.

Six cases are reported in which muscular violence without external trauma caused a fracture in a roentgenographically normal bone. They comprise an impacted fracture of the radial neck in a girl of eleven years; fracture of the lateral malleolus in a man of fifty-three years; two fractures of the ulna in women twenty-three years old; and fractures of the seventh cervical and first thoracic spinous processes. The writer reviews the literature and concludes that prolonged or sudden heavy strain on a single part of the body, particularly in the face of exhaustion or lack of familiarity with the task, may cause spontaneous fracture of almost any bone in the body, even though there is no external violence. The writer concludes that such fractures should be considered accidents and should be compensated as such.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

TREATMENT OF ARTHRITIS DEFORMANS OF THE HIP BY RESECTION OF THE OBTURATOR NERVE. N. Blixenkrone-Møller. *Acta Orthopaedica Scandinavica*, XI, 11, 1940.

The obturator nerve was resected extrapelvically in sixteen cases in which there were degenerative changes of the hip. Nine of these were cases of true arthritis deformans. Dramatic relief of symptoms was obtained in three cases and slight relief in two. The improvement took place in those cases associated with adduction contracture. In seven of the cases the degenerative changes followed congenital dislocation of the hip, coxa plana, etc. In only one of these was there any benefit from the operation. The writer suggests that resection of the obturator nerve be reserved for cases of true arthritis deformans with adduction contracture.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

CAUSALGIC BACKACHE. Otho C. Hudson, Carl A. Hettesheimer, and Percival A. Robin. *American Journal of Surgery*, LII, 297, May 1941.

The authors describe a type of back pain that involves the lumbar muscles, especially the quadratus lumborum. This pain is due to irritation of the twelfth thoracic and first lumbar nerves and radiates along the twelfth rib. A clinical picture of asymmetrical muscle imbalance occurs. This group of cases make up another definite clinical entity, which can be separated from that vast group of patients suffering from back pain. The treatment is simple and effective.

This type of backache is produced by muscle imbalance and muscle spasm, which increase the tension within the quadratus lumborum fascia with direct pressure on the twelfth thoracic nerve, as in the scalenus anterior syndrome. The irritation is manifested by pain with radiation along the course of this nerve. The abdominal muscles become weakened by lack of use, and the overworked sacrospinalis muscles become contracted with an increase of lumbar lordosis and anterior inclination of the pelvis.

The history given by the patient is quite characteristic. It is the history of low-back pain of several years' duration, which is localized in the crest of the ilium and is unilateral. If the pain is right-sided, in many cases appendectomy, gall-bladder surgery, or urological instrumentation have been resorted to without relief. The discomfort continues at night as well as during the day.

Examination reveals increased lumbar lordosis, postural scoliosis, and tilting of the pelvis with abduction of the lower extremity, internal rotation of the thigh, and marked pronation of the foot. There is often hyperaesthesia over the cutaneous distribution of the twelfth thoracic and first lumbar nerves. Tenderness along the twelfth rib is elicited. Tenderness and hyperaesthesia are observed parallel to Poupart's ligament, the upper inner aspect of the thigh, and paravertebrally over the twelfth thoracic and first lumbar transverse processes.

The treatment is rather simple and consists of raising the heel of the abducted extremity to overcome the pelvic tilt. This relaxes the quadratus lumborum and allows the rib to return to normal position, resulting in correction of the scoliosis and disappearance of the internal rotation of the thigh. Exercises for the development of the abdominal muscles and the sacrospinalis group are given.—*O. C. Hudson, M.D., Hempstead, New York.*

Critique on the Inter-relationships of the Osteogenic Tumors. Sheldon A. Jacobson. *The American Journal of Cancer*, XL, 375, 1940.

Under the above title the author presents an elaborate analysis of the various theories of the histogenesis of bone tumors, and offers his own classification, based upon tissues of origin. The classification is developed according to the following scheme:

TISSUE OF ORIGIN	BENIGN TUMOR	MALIGNANT TUMOR
Notochord	Chordoma	
Undifferentiated connective tissue		
Periosteum	Fibroma	Fibrosarcoma
Medullary stroma	Fibroma	Fibrosarcoma
Narrow fat	Lipoma	Liposarcoma
Cartilage	Enchondroma	Chondrosarcoma
Skeletoblastic mesenchyme		
Perichondrium	Ecchondrosis	Chondrosarcoma Osteogenic sarcoma (chondroplastic type)
Periosteum of enchondral bones	Cartilaginous exostosis	Chondrosarcoma Osteogenic sarcoma (variable type)
Periosteum of membranous bones	Ivory exostosis	Osteogenic sarcoma (osteoplastic type)
Endosteum	Osteoid osteoma Giant-cell tumor	Osteogenic sarcoma (osteoplastic type)

The classification is compared with others in the literature in a critical review. An extensive bibliography is appended.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

The Management of Scoliosis. Frederick vom Saal. *The American Journal of Surgery*, LII, 433, June 1941.

Etiological factors in the various types of scoliosis are discussed as paralytic, idiopathic, thoracogenic, neuropathic, and congenital. In the treatment of the postpoliomyelitic curves, it was found that if the curve was progressing before application of the brace, it would continue to do so after application of the brace. The majority of curves in the idiopathic group stopped progressing before cessation of growth. Fusion was done in forty-one patients in a group of 174 with the various types, the patients with postpoliomyelitic scoliosis predominating. Many of these will need fusion for the prevention of deformity. The author uses the Risser type of jacket, with certain modifications. The

jacket is applied with the patient in the maximum bending position toward the concave side of the primary curve, thus straightening the compensatory curves, producing one long curve, and derotating the secondary curves, making the patient straighter and more comfortable. Hinges and turnbuckles are then used for correction. A second modification consists of later rotating the upper part of the cast, so as to bring the shoulder on the convex side of the primary curve forward, after first removing the hinges and turnbuckles. This aids in the correction of rib deformity and brings the spinous processes into a more nearly vertical position—allowing greater ease of operation in the later spine fusion, and better cosmetic results. This does not apply in long-standing cases with severe rotation of the vertebral bodies. The fusion area is determined by studies of the immediately preoperative roentgenogram.

The operation is performed in the usual manner, using the modified Hibbs or Mackenzie Forbes technique, fusing six or seven vertebrae at one time, and using additional bone chips in all cases. Preoperative and postoperative care are discussed.—*Custis Lee Hall, M.D., Washington, D. C.*

Dislocation of the Cervical Spine, Necessitating Fixation at Open Operation. James P. Ainslie. *The Australian and New Zealand Journal of Surgery*, X, 77, 1940.

The author describes a case of forward subluxation of the sixth on the seventh cervical vertebra. The patient had limitation of neck motion, and tingling and pain in the area of distribution of the seventh cervical nerves. With the patient under general anaesthesia and the use of a force of seventy pounds for forty-five minutes, it was impossible to reduce the dislocation. At open reduction the articular facets were levered into place, but, in spite of plaster immobilization, the dislocation recurred after three weeks. This time at open operation, two flanged plates were inserted, which would maintain the reduction even during forcible flexion of the head.—*Daniel H. Levinthal, M.D., Chicago, Illinois.*

The Treatment of Recent Fractures of the Neck of the Femur by Subtrochanteric Osteotomy. A. L. Dawkins. *The Australian and New Zealand Journal of Surgery*, X, 244, 1941.

Since it is generally conceded that there are at least 10 to 15 per cent. of failures in hip pinnings from various causes, the author presents a review of the subtrochanteric osteotomy as the treatment of recent fractures of the femoral neck. Union is more likely to occur as a result of the osteotomy; and, even should it not occur, the patient still has a satisfactory hip, except for a slight amount of shortening and inability to adduct the limb beyond the neutral position. The osteotomy is usually just above the level of the lesser trochanter, permitting the shaft to be displaced medially under the head and acetabulum. With the leg in abduction, a single hip spica is used for three months. Since Whitman's method of reduction and immobilization yields only 60 per cent. to 70 per cent. good results, an immediate osteotomy which will bring satisfactory results in almost 100 per cent. of cases is certainly to be preferred.—*Daniel H. Levinthal, M.D., Chicago, Illinois.*

Fracture of the Neck of the Femur: Pros and Cons of Nailing. John Hoets. *The Australian and New Zealand Journal of Surgery*, X, 278, 1941.

In younger patients, the author is more inclined to use the Whitman method of reduction and immobilization, whereas in older and more debilitated patients, a nailing is preferable. In the operative technique, good roentgenographic control is most essential, and, where available, it shortens the operative time. The McMurray osteotomy is a procedure to fall back upon in cases of unsuccessful nailing. Aseptic necrosis, arthritis, and non-union are not due to the effects of the nail itself. The author describes

a markedly debilitated woman, sixty-three years of age, who withstood the nailing very well, but in whom marked degenerative vascular disease with gangrene of the feet developed. She died four months following the pinning; yet at necropsy, the femoral neck showed excellent union with restoration of the trabeculae, in spite of the fact that the patient's arteriosclerotic vessels produced a gangrene of both lower extremities.—
Daniel H. Levinthal, M.D., Chicago, Illinois.

La patelectomia en el tratamiento de la luxación recidivante de la rótula (Treatment of Recurrent Dislocation of the Patella by Excision of the Knee Cap). Oscar R. Marottoli. *Boletines de la Sociedad de Cirugía de Rosario,* VII, 223, 1940.

This is a very excellent presentation of the subject of recurrent dislocation of the patella. The author believes that it is an anatomical alteration in the structure of the knee joint which allows this displacement of the patella. He feels that the patella is a bone which is gradually being done away with in the evolutionary process of man, and that it is therefore of no use and can be resected with impunity. The various mechanical factors which play a part in the dislocation of the patella are discussed. The author has made tests of muscle strength on patients who have had their patellas removed, and he feels that the strength of the leg is not decreased at all by this operation. The author's technique for removal of the patella is described in detail, and it consists in simply excising the bone, and repairing the defect by stitching the aponeurosis across on each side, and then the quadriceps and patellar tendons. He presents six patients whom he has treated by this method, several of whom have been followed for well over a year. The end results in all of the cases have been excellent, the patients having strong knees and no tendency to any further trouble. The case histories and follow-ups are presented in detail. The article is illustrated with excellent photographs showing the end results in the patients treated. The article offers another and apparently very useful operative procedure for the treatment of recurrent dislocation of the patella.—*Louis W. Breck, M.D., El Paso, Texas.*

Traumatic Expulsion of Astragalus. H. J. McCurrich. *British Journal of Surgery,* XXVIII, 611, 1941.

This is the history of a boatswain on a steam trawler which struck a mine. The patient was blown into the air and then fell into the water. On examination at the hospital it was found that he had a large gaping wound on the inner side of the foot with rupture of all the tendons, vessels, and nerves. The astragalus was missing. Amputation was done through the lower leg, and the patient recovered.

The mechanism of this dislocation is discussed. In this case it was due to a trauma delivered from below rather than to a fall from a height, which is the usual mechanism.—
E. M. Daland, M.D., Boston, Massachusetts.

The Rôle of Vitamin D in the Calcium Metabolism in Osteomalacia. S. H. Liu. *Chinese Medical Journal,* LVII, 101, 1940.

The author observed that the fundamental defect in osteomalacia is due to excessive loss of calcium through the gastro-intestinal canal. The amount of calcium lost by this method may not be great on the daily basis, but if such a loss occurs for a period of time, skeletal decalcification will result. The disease may also occur during periods of increased demand for mineral, especially during pregnancy or lactation. The author feels that disturbance in absorption of calcium in the intestinal tract is due to vitamin-D deficiency. After administration of vitamin D, intestinal absorption of calcium improves, with a decrease of calcium output in the stool and urine. Seven cases have been treated by vitamin D in the form of vigantol, and a high-calcium diet. Most of the patients showed marked improvement.—*Fuang Satyasnguan, M.D., Iowa City, Iowa.*

Congenital Dislocation of the Radius. C. M. Meng. *Chinese Medical Journal,* LVII, 479, 1940.

From this review of the literature it is seen that congenital dislocation of the radius is a rare condition, seen more frequently in the male, with the posterior variety supposed to be more common. The etiology is unknown. Some believe that defective constriction or development of the radiohumeral joint is of significance. It is also believed that heredity is an important factor in the etiology of this condition. In the treatment, reduction is contra-indicated in the great majority of cases. Pressure necrosis may develop when great pressure has been exerted during the manipulation. Many of these cases require no treatment, but when the function of the elbow is very much limited, resection of the upper end of the radius is the treatment of choice.—*Fuang Satyasnguan, M.D., Iowa City, Iowa.*

Treatment of Fracture of the Patella by Excision. Hou Ch'un-chih. *Chinese Medical Journal,* LVII, 482, 1940.

The author claims that excision treatment of the fractured patella lessens the period of convalescence, so that the patient can return to work earlier—two to six weeks after operation—than when other methods are used. He points out that the knee joint still preserves its normal function after removal of the patella. He also describes the method of operation.—*Fuang Satyasnguan, M.D., Iowa City, Iowa.*

One Hundred (100) Cases of Arthritis Treated with a Comparatively Non-Toxic Gold Compound. R. E. Driscoll and D. E. Markson. *Illinois Medical Journal,* LXXVIII, 503, 1940.

The authors cite the work of Mollgaard and Wakerlin who showed that sanocrysin (gold-sodium-thiosulfate), the commonly used gold salt in the treatment of arthritis, is six times as toxic to rabbits as aurol-sulfide, a stable aqueous solution of colloidal gold sulfide. Figured in terms of metallic gold, actually fourteen and one-half units of aurol-sulfide are needed to produce the toxic effects of one unit of sanocrysin. This ratio indicates that colloidal gold sulfide is relatively non-toxic, and larger doses of actual gold may be given in the form of colloidal gold than in the form of crystalloid salts of gold.

The authors treated fifty-one patients with atrophic, and forty-nine with hypertrophic, arthritis by intramuscular and oral administration of aurol-sulfide. These patients were divided into three groups which received varying amounts of gold per patient. Toxic reactions were observed in only two patients, who were also receiving injections of bismuth and arsenic while under the gold-sulfide treatment.

As a result of this treatment, twenty-one patients, or 41 per cent. of the group of fifty-one with atrophic arthritis, and nineteen, or 39 per cent. of the group of forty-nine patients with hypertrophic arthritis, "were definitely improved for the period of this observation". The authors do not state just what this improvement was.

The writers state that this is merely a preliminary report with the primary purpose of ascertaining the degree of toxicity of colloidal gold sulfide. They observed greater improvement when larger doses of gold were used.—*M. S. Friedman, M.D., Iowa City, Iowa.*

Sites of Election for Amputation. (Chapter III of a Handbook on Amputations, in preparation by the Council on Physical Therapy of the American Medical Association.) *The Journal of the American Medical Association,* CXV, 2174, 1940.

This chapter deals with amputations of the lower extremity. Toe amputation results in little or no disability and requires no prosthesis.

Metatarsal amputation sacrifices the normal weight-bearing region of the metatarsal heads. A plantar flap compensates somewhat by retaining soft-tissue integuments

adapted to weight-bearing. Muscular control of the arch is somewhat less efficient, due to loss of the plantar muscles. Leverage and function, consequently, are lost as the site of amputation is moved backwards. Lisfranc's amputation is as far back as one should go. Chopart's amputation is to be condemned as the stump usually goes into an equinus deformity.

Symes' and Pirogoff's amputations require careful surgical technique and neither is likely to succeed in the presence of infection.

The optimum site for amputation of the leg is from five to seven inches below the knee joint.

Amputation through the knee joint has fallen into disuse.

The osteoplastic method of Gritti-Stokes, and the tendinoplastic methods of Callander, and Kirk are satisfactory early, but often come to re-amputation at a later date. They are also difficult to fit with prostheses.

In amputation through the femoral shaft, as much of the bone should be spared as possible.

Disarticulation should be done only as an absolute necessity.

In amputation of the upper extremity as much of the hand should be preserved as possible for later reconstruction.

The forearm should be amputed at the junction of the middle and lower thirds. A terminal scar is satisfactory.—*Maurice Jacobs, M.D., Dallas, Texas.*

EARLY DIAGNOSIS OF MALIGNANT METASTASES TO THE SPINE. A CLINICAL SYNDROME. Samuel A. Wolfson, Samuel Reznick, and Lewis Gunther. *The Journal of the American Medical Association,* CXVI, 1044, 1941.

The authors report seven cases of malignant metastases to the spine with especial emphasis upon the importance of an early diagnosis and the methods of obtaining it. They believe that it is possible to obtain a definite clinical diagnosis in many cases long before roentgenographic evidence is available. A triad of diagnostic criteria is presented: (1) the appearance of radicular pain, persistent and increasing, limited to a narrow zone supplied by one or two roots, and associated with deep percussion tenderness over the spinous processes of the vertebrae bounding the interspaces through which these roots emerge; (2) elevation of the erythrocyte sedimentation rate which appears early, even before changes in the hemogram, and which does not vary proportionately with the amount of marrow involvement; and (3) an increase in the serum-phosphatase level. The authors point out that serial serum-phosphatase determinations may show a significant progressive increase, even though at first examination the values were nearly normal.

Thus, any case in which these criteria are fulfilled may be strongly suspected to be a metastatic lesion of the spine, and, in the presence of a known primary lesion, the diagnosis may be definitely established in the face of negative roentgenographic evidence.

The importance of roentgenotherapy in the relief of symptoms, retardation of the process, and prolongation of life renders such early diagnosis imperative.—*S. L. Stovall, M.D., Dallas, Texas.*

CALCIFICATION OF THE SUPRASPINATUS TENDON. A NEW TREATMENT. G. F. Dick, L. W. Hunt, and J. L. Ferry. *The Journal of the American Medical Association,* CXVI, 1202, 1941.

The authors in this article discuss the etiology, symptoms, and physical findings in calcification of the supraspinatus tendon, and present a new method of treatment which they have found beneficial in several cases.

Contrary to the popular theory that calcification is due to frequent trauma, the authors express the view that calcification may be due to some other factor, namely, a focus of infection. Although this theory is unsupported, symptoms have subsided following removal of focal infections.

The symptoms and physical findings vary with the onset, whether acute or chronic. In both types there is usually pain over the apex of the shoulder, which radiates down the anterior aspect of the arm or to the side of the neck. In the acute form there is considerable muscle spasm, associated with a varying degree of limitation and external rotation. It is emphasized that failure of roentgenographic examination is due to improper placement of the tube.

In the treatment of these individuals surgery is questionable, and excellent results have been obtained by medical management which consists in (1) relatively large doses of ammonium chloride, (2) rest of the diseased part, and (3) physiotherapy and the removal of foci of infection. Ammonium chloride lowers the hydrogen-ion concentration of the blood, thus causing an acidosis of mild degree which in turn causes an absorption of calcium from the tendon. It is given in doses of one gram or more four times a day. Rest of the part is assured by a properly applied arm sling during the day, and by resting the arm on a pillow in abduction at night. Physiotherapy should consist in diathermy. All foci of infection, for example, tonsils, dental infections, prostatitis, et cetera, should be removed.—*S. L. Stovall, M.D., Dallas, Texas.*

PREVENTION AND TREATMENT OF INFECTIONS OF THE HAND. Sumner L. Koch. *The Journal of the American Medical Association*, CXVI, 1365, 1941.

In reviewing and summarizing the results of treatments of open hand wounds sustained by workers in a manufacturing plant located approximately one mile from the hospital with which he is affiliated, the author found that there were sixty-nine such injuries in the past six years. The first-aid rules of the manufacturing plant were followed.

Of forty-seven of these patients who arrived at the hospital immediately after trauma, the injury of only one failed to heal by primary intention and without infection. There were twenty-three patients in whom infection occurred, and in every instance, except the one just mentioned, the employee had failed to report until an average period of three days after the injury.

The author stresses the point that all wounds should be cared for at the time of accident by placing only a sterile dry dressing over the wound, and sending the patient immediately to the hospital.

The first question in regard to infections is whether the infection is diffuse and spreading or localized. After correct diagnosis, it is treated accordingly. All injured tissues should be splinted; this is usually best done by a light aluminum splint which can be molded into desired shape and can be sterilized and incorporated into the dressing.—*D. K. Barnes, M.D., Dallas, Texas.*

MULTIPLE HEMANGIOMAS OF BONE, PROBABLY CONGENITAL. John W. Pierson, George Farber, and John Eager Howard. *The Journal of the American Medical Association*, CXVI, 2145, 1941.

Diffuse osteolytic lesions of the skeletal system are often among the clinician's most difficult diagnostic problems. Even microscopic examination of biopsy material may be inconclusive for exact diagnosis. A patient was recently seen with widespread lesions in which the correct diagnosis was established only by biopsy. The patient was a white male who, from all physical and clinical evidence, was normal except for the roentgenographic findings throughout his entire skeletal system, with the exception of the areas below the knees and below the left elbow. A very thorough and complete examination, including a vast amount of laboratory work, failed to reveal any abnormality.

Diagnosis was made by biopsy of a rib. Differential diagnosis must rule out xanthomatosis diffuse, and osteitis fibrosa cystica (hyperparathyroidism), and osteitis fibrosa disseminata. The one question of most importance to the patient is whether the condition is progressive or not. In the case reported there had been no progression over a five-year period.—*D. K. Barnes, M.D., Dallas, Texas.*

Amputation in Congenital and Chronic Disabilities. Council on Physical Therapy. *The Journal of the American Medical Association*, CXVI, 2159, 1941.

Almost every community contains one or more persons severely crippled by chronic disability, either congenital or acquired, for whom the question of amputation has to be considered. Most of these cases can be classified under any one of the four headings: (1) congenital deformity, (2) posttraumatic deformity, (3) paralysis, and (4) infections.

The Council on Physical Therapy has made it very clear that amputation is a suitable procedure in many cases, but it must be given thought in all cases; this also applies to reconstructive work. There should be sufficient far-sightedness before subjecting the patient to many operative procedures, to judge whether or not the patient will be truly benefited.—*D. K. Barnes, M.D., Dallas, Texas.*

The Kenny Treatment of Infantile Paralysis. A Preliminary Report. Wallace H. Cole and Miland E. Knapp. *The Journal of the American Medical Association,* CXVI, 2577, 1941.

The authors make a preliminary report on the treatment of twenty-six patients with acute anterior poliomyelitis as carried out by Miss Elizabeth Kenny under their observation. Of this number twenty received the Kenny treatment within two weeks of onset. Eleven have already been discharged completely normal, and it is expected that five of the others will recover completely within a reasonably short period of time. One has paralysis of both legs which will probably be permanent.

Of the six patients on whom the Kenny treatment was started from two weeks to two months after the onset of the disease, two have been discharged as permanently well, one will probably have permanent paralysis of one arm, and two are quite likely to have some degree of permanent paralysis.

The principle of the treatment is to combat the muscle spasm, muscle incoordination, and mental alienation which Miss Kenny believes are the cardinal symptoms of the disease. No splints or casts are used. Especially prepared hot foments are applied until the muscle spasm has disappeared. Passive movements through the range of motion possible without pain are carried out several times a day. In addition, an attempt is made to maintain awareness of the part by training once or twice a day as soon as muscle spasm is sufficiently reduced. As the pain is reduced, the muscle training is increased to maintain normal nerve pathways and to restore those which are damaged. By the time the patient is ready to be released from the contagious ward, the pain and spasm are usually gone. Periods of muscle training are carried on twice a day until the patient is normal or ready to be discharged from treatment.—*Brandon Carrell, M.D., Dallas, Texas.*

Compression Treatment of Crush Injuries of Limbs. David H. Patey and J. Douglas Robertson. *The Lancet*, I, 780, June 21, 1941.

The authors report on their experiences in treating crushing injuries of the extremities during bombings of civilian areas. They point out that crushing injuries are often followed by a syndrome consisting of shock, oedema of the affected limb, oliguresis or anuresis, and generally death. They question that this syndrome is due to the liberation of toxic bodies from the crushed tissues and suggest that the reverse may be true, in that on the release of the pressure there is a loss of blood constituents into the injured limb. On this hypothesis they treated two cases by applying intermittent positive pressure up to sixty millimeters of mercury to the oedematous area, using a special large blood-pressure cuff and a pavaex motor. In both cases there was an increase in the output of urine, a diminution of the oedema, and satisfactory recovery. The authors recommend that the treatment be given further trial in crushing injuries and in cases where tourniquets have inadvertently been left too long in position.—*Lenox D. Baker, M.D., Durham, North Carolina.*

Local Concentration of Sulphonamide Compounds Inserted into Wounds. Frank Hawking. *The Lancet*, I, 786, June 21, 1941.

The author describes an investigation of the concentration of sulphonamide compounds: (a) in the wound cavity adjacent to the drug deposit, (b) in the distal parts of the wound cavity, and (c) in the living and dead tissue forming the sides of the wound. He concludes that sulphanilamide has the advantage of high local concentration (maximum about 1500 milligrams per 100 milliliters) and of greater powers of penetration and diffusibility, but the disadvantages of rapid disappearance from the wound and of lower bacteriostatic activity against many of the organisms which may be present. Sulphathiazole persists for a longer period in the wound, and its bacteriostatic activity is much higher than that of sulphanilamide, but it has the disadvantages of expensiveness, of lower concentration (maximum about 180 milligrams per 100 milliliters), and of lower diffusibility. Sulphapyridine possesses no advantage compared with the sulphathiazole, but has the disadvantage of producing still lower concentrations. It is concluded that if a sulphonamide compound is placed in the central cavity of the wound it will pass outward into the prolongations of the cavity, and it will slowly diffuse into dead tissue, but it will not penetrate more than a few millimeters into tissue with an intact circulation. Such tissue is reached more quickly and more effectively by oral administration, as the local application of each of these compounds is limited to the immediate vicinity of the wound cavity.—*Lenox D. Baker, M.D., Durham, North Carolina.*

Air Raid Experiences in the East End of London. Thomas F. Rose. *The Medical Journal of Australia*, II, 690, 1940.

This is an intensely interesting account of the injuries treated by the author during the first month of the bombing of London. Of the 128 cases admitted, twenty-four were orthopaedic in nature. The most serious were compound fractures and perforating joint wounds. All of these were due to crushing by pieces of masonry, concrete, or stones, with much destruction of muscle and skin. There were no limb injuries due to metal flakes from the small shrapnel bomb common in the Spanish Civil War.

Complicating some of these cases were lung blast and crushing injury to the chest. In the former condition the patient did not have signs of lung damage until twenty-four hours after the bomb explosion. The cases of peripheral-nerve paralysis were caused by the concussion effect of blows from flying objects.

The Orr type of treatment was used for the compound fractures. This method has been popularized by Trueta in the late Spanish War. In perforation of joints a thorough débridement was done, and vaselin gauze was packed into the cavity. Non-padded plaster casings were then applied. In all shrapnel wounds the same type of vaselin packing was done, and no closure was attempted. All of the patients were given 3000 units of tetanus antitoxin. In addition, the routine administration of sulfapyridine was carried out as soon as possible following operation. No case of tetanus, gas gangrene, or severe infection developed in this series of patients.—*Harold M. Childress, M.D., Charleston, South Carolina.*

Local Implantation of Sulphanilamide for the Prevention and Treatment of Gas Gangrene in Heavily Contaminated Wounds: A Suggested Treatment for War Wounds. N. J. Bonnin and Frank Fenner. *The Medical Journal of Australia*, I, 134, 1941.

This experimental work was done upon guinea pigs while the authors were in training with a field ambulance corps of the Australian Imperial Force. Treatment was applied in a way which would be practical in war.

Nearly all research workers during the past several years have found that local implantation of sulphanilamide in early compound fractures has either prevented or greatly delayed infection. There is no local irritation, and the consensus of opinion is that the

drug produces no tissue damage. Consequently it does not interfere in any way with the normal healing. This latter opinion was confirmed by the authors by making deep incisions upon guinea pigs and then packing them with the powdered drug. No deleterious effects were noted. Virulent cultures of gas-gangrene organisms were used to infect other fresh wounds. In the treated animals, five-tenths of a gram of powdered sulphanilamide was packed into the wound.

Results showed that locally administered sulphanilamide will control infections with clostridium welchii and clostridium septique, but has only a slight delaying effect on clostridium oedematiens. With mixed infections, surgery combined with the drug gave excellent results.

The authors suggest a routine treatment for war wounds. About twenty grams of the drug should be carried by each soldier. Upon being injured, he should pour the powder into the wound before the first dressing is applied. At the casualty clearing station proper débridement and indicated surgery would then be done.—*Harold M. Childress, M.D., Charleston, South Carolina.*

PARALYSIS OF THE SERRATUS ANTERIOR MUSCLE COMPLICATING DISLOCATION OF THE SHOULDER. George C. V. Thompson. *The Medical Journal of Australia*, I, 231, 1941.

The frequency of nerve injuries complicating dislocation of the shoulder has been estimated to be from 4 per cent. to 55 per cent. Watson-Jones has stated that such sequelae appear in about 14 per cent. of such dislocations. The author has had in the past three months six cases of nerve lesions in thirteen patients having dislocated shoulders.

The neural injury is produced by traction upon the brachial plexus or by direct trauma to an isolated nerve. The axillary nerve is particularly liable to injury because of its exposed course, as is the long thoracic nerve. The writer reports one case of the latter with a consequent paralysis of the serratus anterior muscle. The end result was not known, as the patient refused to submit to prolonged conservative treatment.

A detailed discussion of causes, diagnosis, and treatment of other forms of anterior serratus palsy is given.—*Harold M. Childress, M.D., Charleston, South Carolina.*

ZUR BEHANDLUNGSTECHNIK DER SUPRAKONDYLÄREN HUMERUSFRAKTUR (Treatment of Supracondylar Fracture of the Humerus). K. Schroeder. *Monatsschrift für Unfallheilkunde und Versicherungsmedizin*, XLVIII, 52, 1941.

In a case of supracondylar fracture of the humerus in a child, seven years old, the author was unable to obtain a satisfactory reduction by the customary method of manipulation. He then resorted to a procedure of circumduction of the fragments, by which the lower fragment was displaced from the posterior to an anterior position. With this relationship of the fragments, it was very simple to obtain a proper reduction, which resulted in complete function of the elbow after three months of treatment.—*R. J. Dittrich, M.D., Fort Scott, Kansas.*

COXA PLANA. Donald B. Slocum. *Northwest Medicine*, XL, 233, July 1941.

The author considers coxa plana to be not a disease, but a self-limited syndrome. It is believed to be an aseptic necrosis, resulting from an interference with the blood supply to the epiphysis. This causes a stoppage of growth, and the continuing growing trochanter results in an apparent coxa vara. Of sixty-eight patients, males were four times more numerous than females. The average age was eight and twenty-one hundredths years.

The treatment recommended is conservative, plus a general health-building program. The patient is kept recumbent with traction during the first two stages in recovery,—that is, the stage of condensation and the stage of fragmentation. It is not until

he is well along in the third stage—that of healing—that he is allowed up with braces which prevent weight-bearing completely. This prolonged conservative treatment will provide the differential diagnosis from tuberculosis. No surgical short cut has yet been found to be advisable, although surgery may be performed in the third stage.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

TROCHANTERIC FRACTURES OF THE FEMUR. W. B. McKibbin. *Northwest Medicine,* XL, 242, July 1941.

A method is described of holding trochanteric fractures, especially those fractures in which extensive fragmentation has taken place, and where pins through the neck and head alone are insufficient. The author passes two pins into the neck and femoral head, and these, together with a Roger Anderson half-pin unit inserted below the area of fracture, are all rigidly clamped to a bar and enclosed in a plaster cuff encasing the femur. The knee need not be enclosed. The patient is early mobilized.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

PRIMARY TREATMENT OF WAR WOUNDS. M. N. Akhoutin. *Novy Khirurgichesky Arkhiv,* XLV, 195, 1940.

The method of primary surgical treatment of field wounds was worked out toward the end of the last century. It was then understood as a wide opening of the wound. Pirogoff emphasized the importance of deep incisions with indispensable opening of muscular fasciae. Later on, Bergmann widened the meaning of primary treatment by adding to the technique of incisions the removal of blood clots, foreign bodies, necrosed tissues, and counter incision for drainage. In 1898, Friedreich proved that for six hours the micro-organisms remain within the confines of the wound, and introduced the method of débridement. In the Russo-Japanese war of 1904 to 1905, when 76 per cent. of injuries were from bullet wounds, the method of primary treatment was not used. The World War, with a preponderance of shell wounds, gave an impetus to the forgotten débridement. Friedreich's findings were experimentally confirmed by the French surgeons, and executed with a high degree of success. The method consisted in a complete excision of the wound with subsequent primary suture. Since then, the method has found a very wide application in wounds of civil life in the Soviet Union where primary healing has been reported in 90 per cent. of several thousand cases.

However, adherence to a very exacting technique is essential. The author had the opportunity to observe results of treatments without due consideration to indications in the battles of the Far-Eastern armies. Disastrous results were observed when the time limit of six to eight hours was not observed and when the wound, after a seemingly thorough excision, was closed without drainage.

The author indicates the physical impossibility of excising the wound properly under battle conditions, in which the steady and large numbers of wounded precludes the possibility of a thorough excision as practiced in civilian hospitals. Even if all the prerequisites for a successful débridement were present, the application of sutures would be impossible in all through-and-through wounds with multiple fractures of bone.

The author considers also the wounds of the skull, abdomen, and chest, and indicates the proper management of these wounds.

In order to avoid the mistakes of misapplied débridement in treatment of the extremities, rigid instructions were issued to the field surgeons. The instructions called for a thorough débridement with an economical excision of the skin, removal of all foreign bodies and free fragments of bone, application of a solution of chloramine or rivanol, and immobilization of the extremity. In the presence of joint wounds with fractures, excision of the joint is indicated. Where the soft tissues only are involved, a primary suture of the capsule can be effected, but the skin should not be sutured. The use of antianaerobic sera was apparently not satisfactory.

The author notes the very efficient organization of blood transfusions. More than 7 per cent. of all the wounded received transfusions, and this included almost all of the wounded who needed transfusions.—*Emanuel Kaplan, M.D., New York, N. Y.*

LE TRAITEMENT DES MOIGNONS D'AMPUTATION DOULOUREUX (The Treatment of Painful Amputation Stumps). E.-P. Leclerc. *La Presse Médicale,* XLVIII, 667, 1940.

The author calls attention to the fact that painful amputation stumps may in general be classified into three types,—those characterized by: (1) pain in the stump, itself; (2) pain in the amputated limb; and (3) pain of both types.

Those in the first category are due to painful neuroma, periosteal changes in the bone, etc. Following the lead of Leriche, the author strictly advises against reamputation or plastic surgery of the nerve. Though novocain injection has proved of value, the author urges that the patient should be advised of the possible return of the symptoms. In that event, exposure of the nerve, injection with phenol, amputation of the neuroma, and prompt resuture of the nerve are advocated. However, even in this type of case considerable improvement has been obtained by the procedure which is specifically indicated for cases falling into the second category.

This second group is that in which the patient experiences exquisite pain in the amputated member. Periarterial sympathectomy and novocain injection are of but little avail. It is recommended that preliminary injection of novocain into the lumbar ganglia, in the case of the inferior extremity, or into the stellate ganglia, in the case of the superior extremity, be undertaken for this purpose. If relief of pain is experienced, the author recommends ganglionectomy as the procedure of choice.

In the mixed group the first operation should consist of ganglionectomy, since in itself it may serve to eliminate both the local pain and the radicular pain. A suitable interval should be permitted to elapse between the performance of the ganglionectomy and the amputation of the neuroma, if the second operation is indicated.—*Henry Milch, M.D., New York, N. Y.*

TECHNIQUE DU TRAITEMENT GALVANIQUE DANS LA PARALYSIE INFANTILE (Technique of Galvanotherapy in Infantile Paralysis). H. Bordier. *La Presse Médicale,* XLVIII, 746, 1940.

Physiotherapy in the treatment of acute anterior poliomyelitis consists in the use of radiotherapy, diathermy, and galvanotherapy. In regard to this latter modality, the present technique of immersing the affected part in an electrode bath is completely bad. Employed in this fashion, the galvanic current acts by preference upon the healthy muscles, whose electric resistance is less than that of the involved muscles.

In order to achieve the best results, the author suggests that the parent be instructed to carry out the treatment. For this purpose he has had constructed a portable dry battery, capable of delivering from eight to ten milliamperes of current at a voltage varying from zero to forty-five volts. Because the conductivity of heated muscle is greater than that of unheated muscle, the author suggests a preliminary period of diathermy. The indifferent electrode should be about 100 square centimeters and should be applied at the base of the affected limb. The active electrode should be about twenty square centimeters and should be applied by preference over the affected muscles or their respective motor points. Whether the active electrode should be connected to the positive or the negative pole will be determined by the electrodiagnostic tests. If the muscle exhibits a complete reaction of degeneration, with predominant response on anodal closure, it is to this pole that the active electrode should be connected.

Treatments should be given daily for ten minutes to each segment of the affected limb.—*Henry Milch, M.D., New York, N. Y.*

Considérations sur L'Ostéodystrophie Rénale. A propos d'une Observation Nouvelle (Considerations on Renal Osteodystrophy). Pierre Guye et Erwin Rutishauser. *La Presse Médicale*, XLVIII, 1035, 1940.

The authors report a case of polycystic kidneys in which complete studies including autopsy were made. They note that the nephropathies give rise to a generalized skeletal affection which morphologically resembles the fibrous osteodystrophies. These conditions present appearances seen in hyperparathyroidism, hyperthyroidism, diabetes, and metallic poisoning. All are characterized by an osteolysis, fibrous replacement, and efforts at reparative sclerosis. They are indeed the manifestations of a "demineralization", the exact mechanism of which is not understood.

Attention is called to the fact that von Recklinghausen's disease and renal osteodystrophy may be distinguished by blood chemistry studies. The former is characterized by hypercalcemia and hypophosphatemia, the latter by hypocalcemia and hyperphosphatemia.

Attention is called to the additional fact that though the skeletal lesions are generalized, there may be only local roentgenographic manifestations of the disease. This may be attributed to small traumata such as may be exercised by muscle pull, etc.—*Henry Milch, M.D., New York, N. Y.*

Roentgen Diagnosis of Posterior Dislocation of the Shoulder. Richard A. Rendich and M. H. Poppel. *Radiology*, XXXVI, 42, 1941.

This paper calls attention to the infrequency of posterior dislocations of the shoulder and the difficulty both of the clinical diagnosis and of their recognition in roentgenographic projection made in the anteroposterior plane.

Stereoscopic views are a basic requisite, and a vertical or axial view is of great value. In this dislocation, the lesser tuberosity is rotated and brought into extreme profile medially, at the posterior lip of the glenoid fossa, while the lower third of the fossa is exposed. The humeral head will be found directed posteriorly and medially.—*Edward N. Reed, M.D., Santa Monica, California.*

The Measurement of the Deformity of Alignment Accompanying Fracture. Clayton R. Johnson. *Radiology*, XXXVI, 100, 1941.

This paper outlines a system of measurement for accurately describing the deformity accompanying fracture. Its application to fractures of the wrist, knee, ankle, calcaneum, and shafts of long bones, is illustrated.—*Edward N. Reed, M.D., Santa Monica, California.*

Monomelic Medullary Osteosclerosis of Unknown Etiology. Thomas Horwitz. *Radiology*, XXXVI, 343, 1941.

This is a hitherto unclassified skeletal lesion, monomelic, asymptomatic, unassociated with deformity or alteration in the length of the involved bones. There are no changes in non-osseous structures, and the laboratory findings are normal.

The lesion is a diffuse osteosclerosis, limited almost exclusively to the medullary portion of the bone. The sclerosis extends as far as the articular surfaces, but there is no joint involvement. Histologically the normal spongiosa is replaced by densely sclerotic bone consisting of compact, irregular segments of immature and adult bone arranged in a bizarre pattern. The etiology is unknown, but believed to be a congenital or developmental disturbance of the primitive osteoblastic mesenchyme. One case is described. The condition is differentiated from (1) melorheostosis Léri, a cortical involvement with much periosteal reaction; (2) Paget's disease, in its endosteal form which has characteristic periosteal involvement; (3) the osseous changes in caisson disease; (4) neurofibromatosis; and (5) other osteosclerotic lesions.—*Edward N. Reed, M.D., Santa Monica, California.*

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